A MANUAL

OF

AUSCULTATION AND PERCUSSION

EMBRACING THE

PHYSICAL DIAGNOSIS OF DISEASES OF THE LUNGS AND HEART AND OF THORACIC ANEURYSM AND OF OTHER PARTS

BY

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PREFACE TO SIXTH EDITION

By permission of the son of the late author, the editor is privileged to present this invaluable "Manual" again to the medical student and practitioner.

It is fitting that the final form of a work which went through four editions under the direct revising hand of one of the masters of the science of physical diagnosis should be retained. The principles, the method, the limitations, the practical conclusions of physical examination of the thoracic viscera have never been more clearly nor more effectively described in English. The field of theory, the countless variations in method, the rarities of pathological and clinical experience must still be studied in the great works on diagnosis, to which we must turn for exhaustive discussions. The particular need which this book was intended to fill, and which it is expected that it will again fill, is the demand of the student and of many a graduate in medicine for simplicity, directness, exactness, and authority, in dealing with physical signs in health and disease.

The need of examination of the abdominal viscera and of the nervous system, carried out as carefully as the usual examination of the heart and lungs, excuses the addition of the two chapters dealing with these subjects.

The advantage to be gained in difficult cases, and the accuracy and confirmation to be had in all cases, by the use of various accessory mechanical methods of examination, justifies reference to the principles and methods of these procedures.

For encouragement and assistance in the preparation of this edition the editor is indebted to Dr. Theodore C. Janeway.

HAVEN EMERSON.

NEW YORK, 1912.

INTRODUCTORY

It was with much satisfaction that I gave my hearty approval to the republication, with additions, of Flint's *Manual of Auscultation and Percussion.* This I regard as a fitting tribute to the memory of its distinguished author, as it extends to present and future students of medicine the benefits of the teachings he so loved to impart.

The letter-press has been retained with but slight alteration, for the book was a masterpiece of clarity and precision. Few medical writers have been gifted with the elegance of diction illustrated in this little work.

The additions by the editor to the original chapters embrace certain new and valuable methods of examination that have arisen within the last twenty-five years.

In the interest of completeness new chapters have been added, giving methods of physical examination of the abdominal viscera, and of the nervous system.

Austin Flint.

New York, 1912.

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PHYSICAL EXPLORATION

The physical examination of the chest embraces six different methods—namely, inspection, palpation,

mensuration, percussion, auscultation, and succussion. Of these, percussion, auscultation, and succussion dealing with sounds involve the sense of hearing. In percussion the sounds are produced by striking upon the walls of the chest; in auscultation, they are caused by acts of breathing, speaking, and coughing, in succussion they are caused by splashing of fluids when the body is shoved abruptly, or shaken.

The sounds in auscultation and percussion are (1) normal or healthy sounds, being produced when there is no disease of the chest; and (2) abnormal or morbid sounds, being produced when the chest is the seat of disease. The sounds, healthy and morbid, constitute what are known as physical signs. Frequently, for the sake of brevity, the term signs, without the word physical, is used to denote these sounds. Conventionally, physical signs, or signs, are terms employed in a sense of contradistinction to the term symptoms. The signs are distinguished, of course, as normal or healthy, and abnormal or morbid.

The sounds which constitute signs represent certain physical conditions pertaining to the chest. The normal or healthy signs represent physical conditions existing when the organs are not affected by disease; the abnormal or morbid signs represent physical conditions which are deviations from those of health, being incident to the various diseases of the chest. The physical conditions represented by signs may be distinguished as normal or healthy, and abnormal or morbid conditions.

The representation of healthy and morbid physical

conditions by certain healthy and morbid signs is established by having ascertained a constancy of association of the signs with the conditions. This constancy of association is ascertained by observation or experience. The sounds obtained by percussion and auscultation in health are thereby established signs of healthy conditions, and the sounds obtained only in cases of disease are thereby established signs of morbid conditions. Our knowledge of certain sounds as the signs of certain physical conditions can have no reliable basis other than the constancy of the connection of the former with the latter. This constancy of connection is determined by the study of the sounds during life and examination of the organs after death. The existence of certain conditions is not to be inferred from the characters of certain sounds until the connection of the sounds with the conditions has been ascertained by experience; then, and then only, are the sounds to be reckoned as signs of these conditions. So, also, it is not to be inferred from certain physical conditions found after death, that certain sounds must have been produced during life, until the connection between the conditions and the sounds has been ascertained by experience. In other words, our knowledge of signs as representing physical conditions, can rest on no other than a purely empirical foundation.

Our knowledge of the signs representing the physical conditions in health and disease, thanks to the labors of Laennec, and of those who have followed in his footsteps, has been brought to great perfec-

tion.[1] The practical object of this knowledge is to determine by means of auscultation and percussion, together with the other methods of exploration, the existence of either healthy or morbid physical conditions, and to discriminate the latter from each other; that is to say, the practical object is diagnosis. The signs now known to represent physical conditions, healthy and morbid, taken in connection with symptoms and pathological laws, render, for the most part, the diagnosis of diseases of the chest easy and positive. Hence, it becomes the duty of the medical student and practitioner to give to auscultation and percussion attention sufficient, at least, for their practical application to the diagnosis of the diseases commonly met with in medical practice; and this duty is the more imperative because it involves neither peculiar difficulties nor great labor. In entering upon the undertaking it is important to consider the requirements for the successful study of this province of practical medicine. These requirements relate to: (1) the anatomy and physiology of the chest; (2) the morbid physical conditions incident to the different diseases of the chest; (3) the distinctive character of healthy and morbid signs; and (4) the signifiance of the signs as regards the physical conditions which they severally represent.

[1] We owe a debt also to Auenbrugger, who preceded Laennec, and to Wintrich, Skoda, Traube, and Gerhardt particularly among his successors.

ANATOMY AND PHYSIOLOGY OF THE RESPIRATORY ORGANS

The necessity of a knowledge of the antomy and physiology of the chest, as a requirement for the study of auscultation and percussion, together with the other methods of physical exploration, is too obvious to need any discussion. The physical conditions of health must be known as preparatory for appreciating the physical conditions of disease. It would be absurd to think of studying the latter until the former are known. The student, therefore, who is not acquainted with the anatomy and physiology of the chest, must defer entering upon the study of physical diagnosis until this requirement is fulfilled. Familiarity with the morbid physical conditions is necessary; and for the advanced medical student or the practitioner it is advisable to refresh the memory with a reviewal of certain anatomical and physiological points before beginning the study of auscultation and percussion. These points, relating especially to the physical conditions of health, cannot be considered in this work. A simple enumeration of them only can be introduced, the reader being referred for details to treatises on anatomy and physiology.

Important anatomical conditions relate to the bones of the chest—namely, the general conformation of the thorax, the differences in respect of the obliquity of the ribs from above downward; the direction of the costal cartilages, their connection with the sternum, and the angles formed by the junction

of the ribs and cartilages; the differences in width of the intercostal spaces in the upper, middle, and lower portions of the anterior, lateral, and posterior aspects of the thorax, together with the relations of the scapula and clavicle. The relative thickness of the muscular covering of the chest in different situations is to be considered, and, in women, the varying size of the mammæ. The attachments of the diaphragm to the thoracic walls, and its relations to the organs below, as well as above it, are points of importance (Figs. 1, 2, 3, 4).

Important physiological conditions relate to the parts which the ribs, costal cartilages, sternum, and diaphragm severally play in the movements of respiration. The differences, in respect of these movements, in tranquil and in forced breathing, the contrast between the two sexes, and between early and advanced life, are points to be studied. Other points are, the frequency of the respirations in health, and the relative duration, rapidity, and force of the inspiratory and the expiratory movements.

Certain anatomical and physiological points pertain to the organs within the chest. The more important of these, relating to normal physical conditions, are the following: (1) As regards the lungs, the connections of the pleura, and the smoothness of the pleural surfaces in contact with each other; the relations of the apex and base of each lung to the chest-walls, and the differences of the two lungs in this respect; the relative spaces occupied respectively by the two lobes of the left, and the three lobes of the right lung;

the situation of the interlobar fissures in either side on the posterior, lateral, and anterior aspects of the chest; the arrangement of the air-vesicles, pulmonary lobules, and the different-sized intra-pulmonary bronchial tubes; the expansion of the air-vesicles, and the movement of the current of air from larger to smaller bronchial tubes in the act of inspiration, the vesicles diminishing in size, and the current of air moving from smaller to larger tubes in the act of expiration; the difference in respect to the relative proportion of air and solids at the end of inspiration and at the end of expiration; the extent to which the volume of the lungs may be diminished by a forced act of expiration, and increased by a forced act of inspiration; the relations of the apices to the subclavian arteries, and the variable extent to which the apex rises on either side above the clavicle. (2) As regards the larynx, trachea, and the bronchial tubes without the lungs; the anatomy and physiology of the vocal chords; of the muscles concerned in the movements of respiration and of phonation, with the relations of each to the recurrent laryngeal nerve; the size of the rima glottidis in youth, after puberty, and relatively in the two sexes; the enlargement of the rima in the act of inspiration, the diminution of its size in the act of expiration, and the closer approximation of the chords in the act of coughing; the difference in the amount of areolar tissue above the vocal chords in children and in adults; the situation of the trachea and the point of its bifurcation; the length, direction, and size of the two primary bronchi

contrasted with each other, and the branches which penetrate the lungs. (3) As regards the heart, the boundaries of the space which it occupies—that is, of the precordial space; the relation of the aorta and pulmonic artery to the walls of the chest; the portions of the precordial space in which the heart is covered and uncovered by lung; the situations of the auricles and ventricles respectively; the relations of these to each other, and the arrangements of the valves; the currents of blood through the orifices within the heart, and the relations of each of these to the heart-sounds; the rhythmical succession of these sounds; the differences which distinguish each from the other in respect of loudness, duration, tone, quality, extent of diffusion, and the situation in which each has its maximun of intensity; the mechanism of these sounds, and the situation of the apex-beat (Figs. 1, 2, 3, 4).

The foregoing are the anatomical and physiological points which especially claim attention with reference to normal physical conditions, preparatory to entering on the study of abnormal physical conditions represented by the signs furnished by auscultation and percussion together with the other methods of physical exploration.

It is recommended to the student, before proceeding farther, either to acquire or review knowledge respecting all these points. Knowledge of these should be made familiar, if it be not already so, by reference to works treating of the anatomy and physiology of the chest.

THE MORBID PHYSICAL CONDITIONS INCIDENT TO THE DIFFERENT DISEASES OF THE RESPIRATORY SYSTEM

The various morbid physical conditions incident to different diseases must be known, for it is the immediate object of auscultation, percussion, and the other methods of exploration, to ascertain either the existence or the absence of these morbid conditions. Knowledge of all the important conditions which are deviations from those of health, and the relations of each to different diseases, is, therefore, an essential requirement.

Deviations from the normal conformation of the chest and the various abnormal movements of respiration, belong properly among the physical signs obtained by inspection, palpation, and mensuration. For the most part, these signs represent morbid physical conditions within the chest. Certain conditions relate to the presence of liquid, either serous, sero-fibrinous, or purulent, within the pleural sac. The quantity of liquid may be large enough to compress the lung into a solid mass, and to enlarge the affected side, at the same time restraining or annulling the respiratory movements; the chest on the affected side, then, will contain only lung solidified by compression, and liquid. In other cases the quantity of liquid is either small, moderate, or considerable, the lung then containing a lessened quantity of air, and its volume diminished in proportion to the amount

of liquid. These morbid conditions are incident to simple pleurisy with effusion, pyothorax or empyema, and hydrothorax.

The pleural surfaces, in cases of pleurisy, may be more or less covered with recent fibrinous exudation, and, when not separated by the presence of liquid, they do not move upon each other smoothly and noiselessly. The friction of the opposed surfaces is still more productive of audible and sometimes tactile signs after the absorption of liquid, when the exudation has become more adherent and dense than when it is recent.

The presence of air in the pleural space, either alone or with more or less liquid, in pneumothorax, may compress the lung into a solid mass, also dilating the affected side, and restraining or annulling its movements; and the air, with or without liquid, when not in sufficient quantity to produce these effects, may diminish more or less the volume of the lung and the amount of air in the pulmonary vesicles. These morbid conditions give rise to characteristic physical signs. The perforation of lung, usually existing in cases of pneumothorax, occasions additional signs which are characteristic.

Solidification of lung is an important physical condition incident to several diseases, irrespective of the condensation, just referred to, caused by the compression of liquid or air in the pleural sac. Complete consolidation of an entire lobe, or of two and even three lobes, exists in the second stage of lobar pneumonia. Certain physical signs represent this

condition of complete solidification.[1] The different degrees of solidification, namely, slight, moderate, and considerable, occur during the stage of resolution in cases of pneumonia, and these gradations are severally represented by well-defined characters pertaining to physical signs. Solidification, circumscribed, forming nodules which vary in size and number, situated in the upper, lower, or middle portion of the lung, either on one side or on both sides, exists in phthisis, in broncho-pneumonia and collapse of pulmonary lobules, in hydatids, in hemorrhagic infarctus and embolic pneumonia, in pulmonary gangrene, and in primary and secondary neoplastic growths. It exists, greater or less in degree and more or less extended, in interstitial pneumonia. In these different connections the existence of solidification, its degree and extent, its limitation to one situation or its existence at different points, are determinable by means of physical signs.

A morbid condition the opposite of solidification is an abnormal accumulation of air within the air-vesicles of the lungs. This is incident to pulmonary or vesicular emphysema, involving a morbid dilatation of the air-vesicles. The permanent expansion and increased volume of the upper lobes in some

[1] The term complete consolidation as used here is not intended to indicate a filling of the large subdivisions of the bronchi with exudate in the affected lobe. This extreme condition may occur and is described as massive consolidation. In this form certain of the physical signs are markedly altered, the breath and voice sounds being diminished or entirely suppressed.

cases of this disease, occasion a characteristic deformity of the chest, together with certain deviations from the normal movements of respiration, which are also characteristic. This morbid condition is represented by distinctive signs furnished by auscultation and percussion. The extravasation of air in the connective tissue, constituting interlobular and subpleural emphysema, in like manner gives rise to signs furnished by these methods of exploration.

The presence of a viscid exudation within the air-vesicles and bronchioles, is a morbid physical condition incident to acute pneumonia, especially in its first stage, agglutinating the cells and bronchioles, the walls of which may be brought into contact or close proximity at the end of the act of expiration. The separation of the walls thus agglutinated, in the act of inspiration, gives rise to an auscultatory sign (the crepitant râle).

An accumulation of serum within the air-vesicles constitutes the condition called pulmonary edema. This condition gives rise to signs furnished by auscultation and percussion.

Liquid within the bronchial tubes (serum, pus, blood, or thin mucus) is a condition incident to pulmonary edema, abscess either of the lung or situated elsewhere and evacuating through the bronchial tubes, phthisis, bronchorrhagia, pneumorrhagia, bronchorrhea, and bronchitis. The passage of air through the different varieties of liquid in the tubes causes bubbling sounds which are appreciable in auscultation. The apparent size of the bubbles (coarseness or

fineness) denotes the size of the tubes in which they are produced, and the pitch of the bubbling sounds denotes either solidification or otherwise of the pulmonary substance surrounding the tubes in which the bubbles are produced. Bubbling sounds more intense and on a larger scale are caused by the presence of liquid within the trachea and larynx, known as the tracheal râles or the death rattle.

Diminished calibre of the bronchial tubes within the lungs, either localized or diffused, is a condition due to the presence of tenacious mucus, and the swelling of the mucous membrane in cases of bronchitis. In cases of so-called capillary bronchitis the condition may involve an alarming degree of obstruction. The same morbid condition is incident to bronchial spasm in asthma, occasioning in this disease great suffering, but without immediate danger. The condition is represented by auscultatory signs which enable the auscultator to differentiate the obstruction due to capillary bronchitis from that due to bronchial spasm. Permanent obliteration of more or less of the bronchial tubes is an occasional morbid condition.

Obstruction of a bronchial tube, either within or without the lung, is a morbid condition involving the loss of respiratory sound within the area of the bronchial branches and vesicles not receiving air in consequence of the obstruction. The obstruction may be temporary, being caused by a plug of mucus of sufficient size to prevent the passage of air; the morbid condition is then incident to bronchitis. One of the primary bronchi may be obstructed temporarily

by a plug of mucus, and obstruction of the larynx in childhood thus produced may be sufficient to cause death by suffocation. The inhalation of foreign bodies is another cause of obstruction within the larynx, trachea, or bronchi. A primary bronchus or the trachea may be pressed upon by an aneurismal or other tumor, and, in this way, more or less obstruction to the passage of air is produced. However produced, the situation of the obstruction and its degree are, in general, determinable by means of auscultatory signs.

Dilatation of bronchial tubes occasions two morbid physical conditions differing as regards their auscultatory signs—namely, (1) an enlargement of greater or less extent, the tubes preserving their cylindrical form; and (2) a sacculated enlargement. The former occurs generally in connection with solidification around the tubes from hyperplasia of the areolar tissue, and is thus incident to interstitial pneumonia. The latter may give rise to signs which represent pulmonary cavities.

Sacculated dilatations of bronchial tubes, and the cavities incident to phthisis, pulmonary abscess and circumscribed gangrene of lung, are represented by well-marked and highly distinctive signs furnished by auscultation and percussion. The signs denote either that cavities have flaccid walls which collapse in expiration and expand in inspiration, or that, owing to solidification of lung, they remain open during both acts of respiration.

More or less of the space within the chest which,

normally, is occupied by lung, may be encroached upon by aneurisms or other intra-thoracic tumors. This is a physical condition giving rise to notable morbid signs furnished by auscultation and percussion.

Finally, an extremely rare morbid physical condition is the presence of more or less of the hollow viscera of the abdomen within the chest, in consequence of either a congenital deficiency in the diaphragm, or a wound penetrating this muscle (diaphragmatic hernia).

The foregoing morbid physical conditions relate to the respiratory organs. Those relating to the heart are deferred in order that they may precede more immediately an account of the signs of cardiac disease. As a requirement for the study of morbid physical signs, the foregoing morbid physical conditions must be understood and memorized. To assist the student in the latter, a summary of these conditions is appended.

SUMMARY OF MORBID PHYSICAL CONDITIONS INCIDENT TO DISEASES OF THE RESPIRATORY ORGANS

1. An accumulation of serous, sero-fibrinous, or purulent liquid sufficient to fill the affected side of the chest, and sometimes causing more or less enlargement.

2. An accumulation of liquid partially filling the affected side of the chest, the quantity being either small, moderate, or considerable.

3. Fibrinous exudation on the pleural surface.

4. Air with liquid within the pleural cavity, and perforation of lung.

5. Air without liquid in the pleural cavity.

6. Solidification of lung, either complete or approximating to completeness.

7. Solidification of lung, slight or moderate in degree.

8. Dilatation of the air-vesicles, involving within them an abnormal accumulation of air.

9. Extravasation of air within the pulmonary connective structure.

10. Exudation within air-vesicles and bronchioles.

11. Liquid within air-vesicles.

12. Liquid (mucus, serum, pus, or blood) within bronchial tubes of large, medium, or small size.

13. Liquid within bronchial tubes of minute size.

14. Obstruction of the pulmonary bronchial tubes by mucus, swelling of the mucous membrane, and spasm of the bronchial muscular fibres.

15. Obstruction of larynx, trachea, or bronchi exterior to the lungs, by plugs of mucus or foreign bodies.

16. Obstruction of the trachea or a primary bronchus by aneurismal or other tumors.

17. Dilatation of bronchial tubes, cylindrical or sacculated.

18. Pulmonary cavities.

19. Tumor within the chest.

20. Diaphragmatic hernia.

THE DISTINCTIVE CHARACTERS OF HEALTHY AND MORBID SIGNS

For the practice of auscultation and percussion it is essential to be able to recognize the signs, severally, which represent the different physical conditions in health and disease. It is essential to distinguish the morbid from the healthy signs, and to discriminate from each other, severally, the signs of disease. The recognition and discrimination of signs require knowledge of the distinctive characters belonging to each of them. In entering upon the study of the signs, therefore, it is a necessary requirement to know whence their distinctive characters are derived. To this point of inquiry the attention of the student is now invited.

The signs being sounds, they are to be recognized and discriminated in the way in which we practically recognize and discriminate other sounds. It is not necessary, in order to do this, to study the science of acoustics. In becoming familiar with other sounds, for example, musical notes produced by different instruments, or the varieties of the human voice, we do not have recourse to that science. It suffices for all practical purposes to contrast the sounds obtained by auscultation and percussion with reference to very simple and obvious differences; and, yet, it is necessary to understand very clearly in what these differences consist, or, in other words, the sources of the distinctive characters of these sounds. The

more important of the differences between the sounds obtained by auscultation and percussion relate to intensity, pitch, and quality. The distinctive characters of most of the signs are derived from these three sources. In becoming practically acquainted with the signs, they are to be contrasted as regards intensity, pitch, and quality, precisely as we would bring other sounds into contrast in these three aspects. The distinctive characters of the signs, severally, are especially derived from their differences in these respects. The distinctions expressed by the terms intensity, pitch, and quality are, therefore, to be made clear.

Differences in the intensity of sounds are easily understood. One sound is more intense than another sound when it is simply louder, and varying degrees of intensity are expressed by such terms as feeble or weak and loud, to which may be prefixed adjectives of quantity, such as very, moderate, etc. This is all that need be said with reference to the first of the three aspects under which sounds are contrasted. It will be seen hereafter that intensity is an essential element in the distinctive characters of certain of the signs.

Differences in the pitch of sounds are easily understood by those who have given any attention to music. The differences are expressed by the terms high and low, to which may be prefixed words denoting a greater or less degree of highness or lowness. A nice appreciation of variations in the pitch of musical notes, requires what is known as a "musical ear;" but a

very nice appreciation is not essential in comparing, as regards pitch, the sounds studied in auscultation and percussion. For the most part, these sounds are not musical notes; nevertheless, differences in pitch are readily perceived. A musical ear is undoubtedly an advantage in readily distinguishing differences in pitch; but it is by no means a *sine qua non.* For those who have given no attention to music, some difficulty may be at first experienced in judging correctly of differences in this regard; but the difficulty disappears after a little practice. Differences in pitch now enter pretty largely into the distinctive characters of physical signs; but by Laennec, and those who immediately followed him, comparatively little attention was paid to the study of signs with reference to these differences. The writer was led to engage in this study more than a quarter of a century ago, and hereafter, in giving an account of the different signs, he will claim to have been the first to have clearly indicated certain characters from this source.[1]

Differences relating to quality are apt, at first, to be confounded with those relating to pitch; hence the distinction between pitch and quality must be clearly understood. We may say of the quality of a sound, that it embraces whatever is not embraced in the terms intensity and pitch. This is true as a general statement. The sense of the term quality, in distinction from intensity and pitch, may be most

[1] *Vide* Prize Essay on "Variations of Pitch in Percussion and Respiratory Sounds, and their Application to Physical Diagnosis." Transactions of the American Medical Association, 1852.

readily made clear by an illustration. Let it be supposed that we hear the notes of an instrument which is unseen—the performer, for example, being in another room. We recognize at once the instrument by the notes, provided it be one with which we are familiar, such as a violin, a flute, a clarionet, etc. We do not need to see the instrument; we recognize it by the sounds. Now, how do we recognize it? Certainly not by the intensity of the sounds; it matters not whether these be loud or weak, so that we hear them. Certainly not by the pitch; for if a piece of music be performed, we get both high and low notes. We recognize the instrument by the quality of the sounds. Each musical instrument, owing to its peculiarity of construction, yields sounds which are peculiar to it; and after we have become familiar with the quality of sounds peculiar to an instrument, we immediately thereby recognize it. Precisely in the same way we may recognize certain sounds produced by auscultation and percussion in health and disease. The signs differ in quality according to the physical conditions which they severally represent; and differences in quality will be found hereafter to constitute essential and obvious distinctions by which the signs of health and disease are recognized and discriminated. This is a source ot some of the most distinctive of the characters of certain of the physical signs.

Of the peculiar quality of any particular sound one can form no definite idea otherwise than by direct observation. That is to say, no one could describe to another the peculiar quality of a particular sound

so that it would be clearly apprehended without the sound having been heard. Imagine the attempt to describe the sound of a violin to a person who had never listened to the notes from that instrument—it would be impossible to give a correct idea of it in language. The only way in which an approximate idea could be conveyed in words, would be by comparing the quality to that of some other instrument to the notes of which there was some resemblance—that is, by analogy. To attempt to describe the quality of sounds to one who had never heard them would be like describing colors to one blind. It will be seen hereafter that the quality of certain sounds obtained by auscultation and percussion is peculiar to them, and their distinctive characters in this respect can be known only by direct observation; they cannot be learned by means of any verbal description, nor by any comparisons—that is, by analogy.

Appreciable variations in the quality of sounds are infinite. This may be illustrated by the human voice. Almost every person may be recognized from a peculiar quality of the voice by one who is familiar with it; and the voices of thousands of persons, if compared, would present shades of difference—in fact, as is well known, it is extremely rare for the voices of any two persons to be so nearly identical in quality that they cannot be distinguished from each other. As the diversity in quality of different sounds cannot be described, so they can only be designated by names which are significant from certain resemblances. Terms based on analogies which

are used to denote qualities of the sounds furnished by auscultation and percussion are the following: rough, harsh and rude, soft, blowing, hollow, musical, moist, dry, bubbling, gurgling, crackling, clicking, rubbing, grating, creaking, tubular, cracked metal, sibilant or whistling, sonorous or snoring. All these names owe their significance to resemblances to other sounds. One sound furnished both by auscultation and percussion has a quality which is *sui generis*, and the term used to distinguish it is derived from its source, namely, the vesicular resonance, and the vesicular murmur of respiration.

In addition to intensity, pitch, and quality as sources of the distinctive characters of the signs furnished by auscultation and percussion, there are some other points of difference, namely, the duration of certain sounds; their continuousness or otherwise; their apparent nearness to, or distance from, the ear; their rhythmical succession, and their strong resemblance to particular sounds, such as the bleating of the goat, the chirping of birds, etc. These points of difference are important, although less so than those relating to intensity, pitch, and quality.

The study of the different sounds furnished by auscultation and percussion, with reference to distinctive characters relating especially to intensity, pitch, and quality, distinct signs being determined from points of difference as regards these characters, may be distinguished as the analytical method. It may be so distinguished in contrast with the determination of signs deductively, taking as a standpoint

either the physical conditions incident to diseases or the sounds. If we undertake to decide, *a priori,* that certain sounds must be furnished by auscultation and percussion when certain conditions are present we shall be led into error; and so, equally, if we undertake to conclude from the nature of the sounds that they must represent certain conditions. The only reliable method is to analyze the sounds with reference to differences relating especially to intensity, pitch, and quality, and to determine different signs by these differences, the import of each of the signs being then established by the constancy of association with physical conditions. It is by this analytical method only that the distinctive characters of signs can be accurately and clearly ascertained. This is to be borne in mind by the student in physical exploration. He is to become acquainted with the different signs, and to recognize them in practice, by acquiring a knowledge of the distinctive characters of each, as derived mainly from differences relating to intensity, pitch, and quality. The individuality of the signs, severally, can rest on no other solid basis.

THE SIGNIFICANCE OF THE SIGNS AS REGARDS THE PHYSICAL CONDITIONS WHICH THEY SEVERALLY REPRESENT

Knowledge of the significance of the physical signs is the complemental requirement in the study of auscultation and percussion. For the successful

employment of these methods, in addition to the recognition of each sign by its distinctive characters, must be known its significance, that is, the physical condition which it represents. In this respect the signs may be compared to the substantives in language, each having a definite meaning. The signs furnished by these methods may be said to constitute a language with a very small vocabulary; or, taking as the standpoint the things signified, the different physical conditions are expressed by means of the signs.

It is to be noted that the significance of the morbid signs relates immediately, not to diseases, but to the physical conditions incident thereto. Very few signs are directly diagnostic of any particular disease. They represent conditions not peculiar to one, but common to several, diseases. Thus, solidification of lung exists in pneumonia, phthisis, pleurisy with effusion, collapse, and pulmonary neoplasm; now, certain signs tell us that this morbid condition exists, together with its situation, its degree, and its extent. With this information the diagnosis of the disease is made by connecting with it pathological laws, together with the history and symptoms. The student in physical exploration should by no means imagine that, for the diagnosis of diseases, exclusive reliance is to be placed on the signs; they are always to be taken in connection with pathological laws, the history, and the symptoms. Disconnected from these, the signs would often lead to error, and it is no disparagement to physical diagnosis that its reliability

depends on other facts than those which belong exclusively to it.

To repeat a statement already made more than once, the significance of the signs, as regards the conditions which they severally represent, is based on the constancy of their association with the latter, our knowledge of this association being derived from examinations during life and after death.

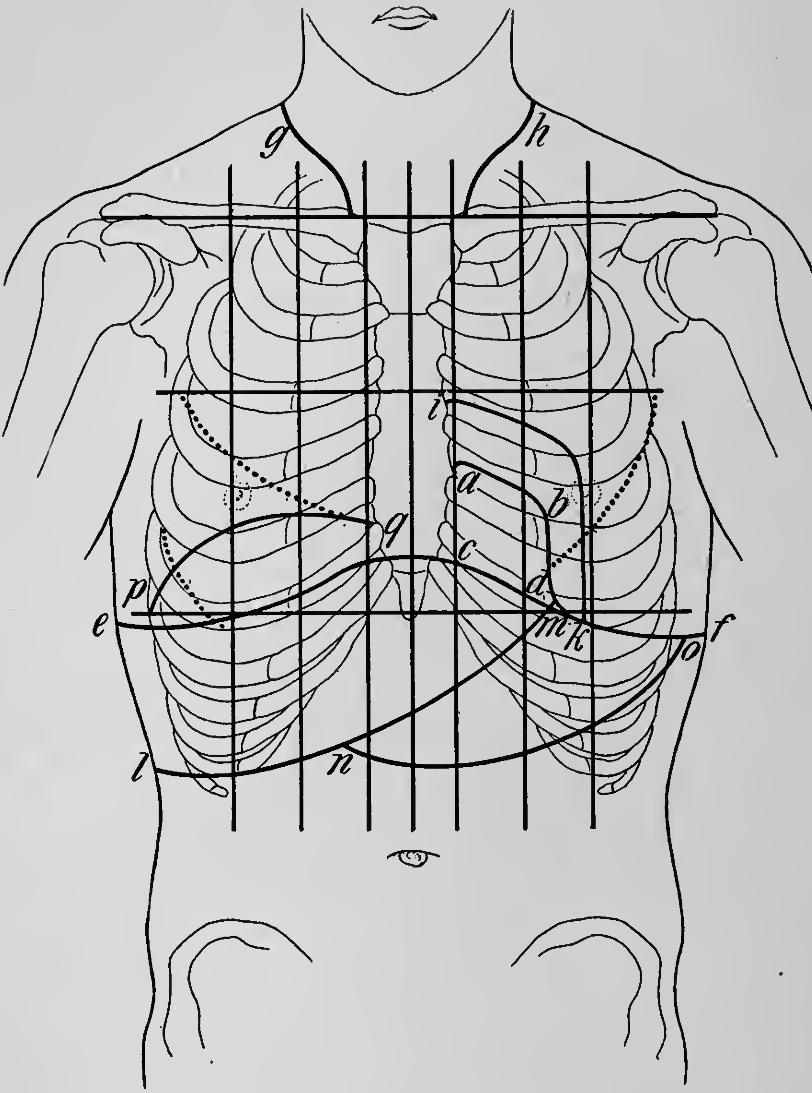
REGIONAL DIVISIONS OF THE CHEST

Before entering on the study of physical exploration, the student should become acquainted with the divisions of the surfaces of the anterior, posterior, and lateral aspects of the chest into circumscribed spaces which are called regions. These divisions, deriving their boundaries and names from their anatomical relations, are sufficiently simple.

Anteriorly the chest is divided into regions as follows: The supra- or post-clavicular region extends from the clavicle upward a short distance, corresponding to the variable height to which the lung rises above this bone. The clavicular region embraces the space occupied by the clavicle. The infra-clavicular region embraces the space between the clavicle and the third rib. The mammary region is bounded above by the third and below by the sixth rib, and the inframammary region is the portion of the chest below the sixth rib.

Posteriorly the divisions are into the scapular, the infra-scapular, and inter-scapular regions. The

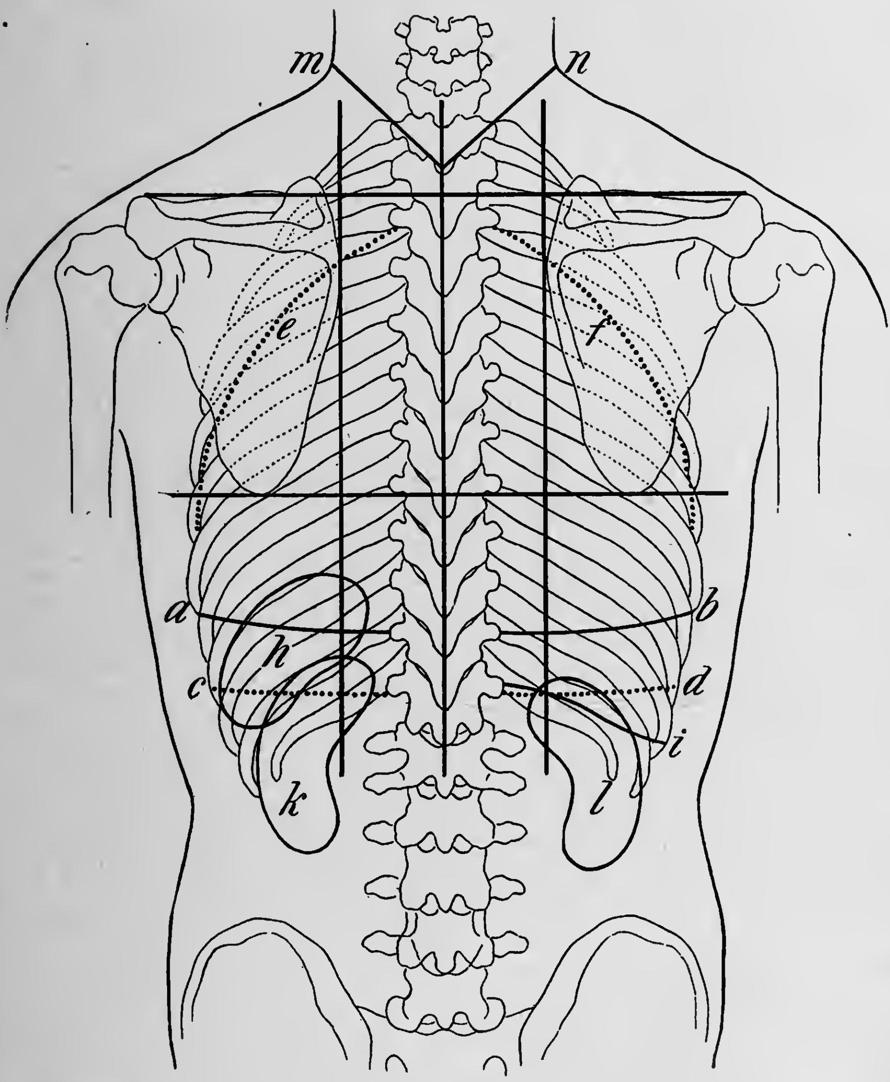
Fig. 1



The horizontal lines indicate the boundaries of the regional divisions on the anterior aspect of the chest. The vertical lines are the midsternal, or anterior median line; the right and left sternal lines, the right and left parasternal lines, and the right and left midclavicular lines (the latter representing a term formerly and less accurately used, namely, the mammillary line). The oblique dotted lines indicate the interlobar fissures: *ab*, *ac*, *cd*, and *bd*, boundaries of superficial cardiac space; *ik*, outer boundary of deep cardiac space; *ce*, lower boundary of right lung; *df*, lower boundary of left lung; *gh*, upper boundary of right and left lung; *lm*, lower boundary of hepatic flatness; *pq*, upper boundary of hepatic dulness; *no*, lower boundary of the stomach moderately distended.

scapular region is the space occupied by the scapula and is divided by the spinous ridge into the upper

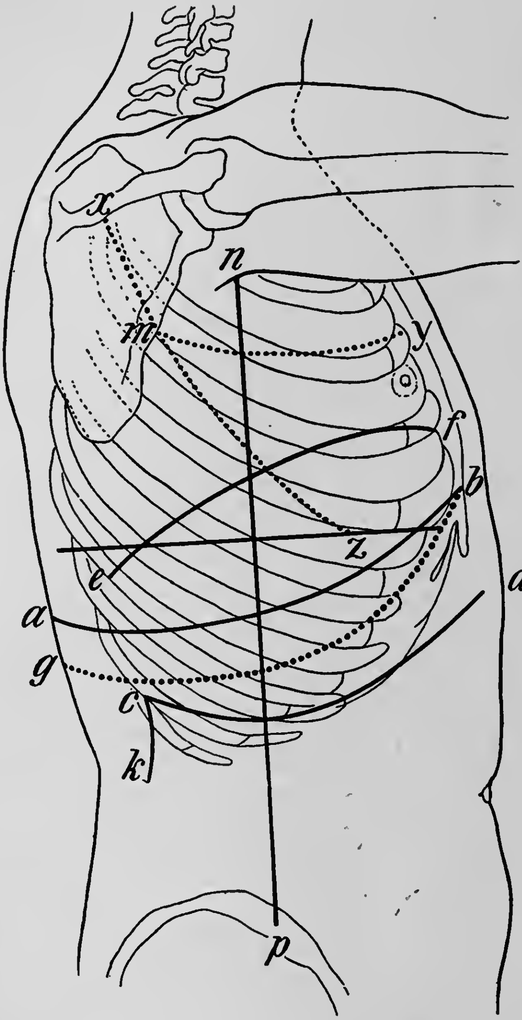
FIG. 2



The longitudinal and vertical lines indicate the regional divisions on the posterior aspect of the chest. The vertical lines are called the vertebral or posterior median line, and the right and left scapular lines: *ab*, lower boundary of lungs; *cd*, lower limit of expansion of lungs; *ef*, interlobar fissures; *h*, spleen; *i*, lower boundary of liver; *k*, left kidney; *l*, right kidney; *mn*, upper boundary of left and right lung.

and lower scapular space. The infra-scapular region is the portion below a horizontal line intersecting the lower angle of the scapula. The inter-scapular

FIG. 3

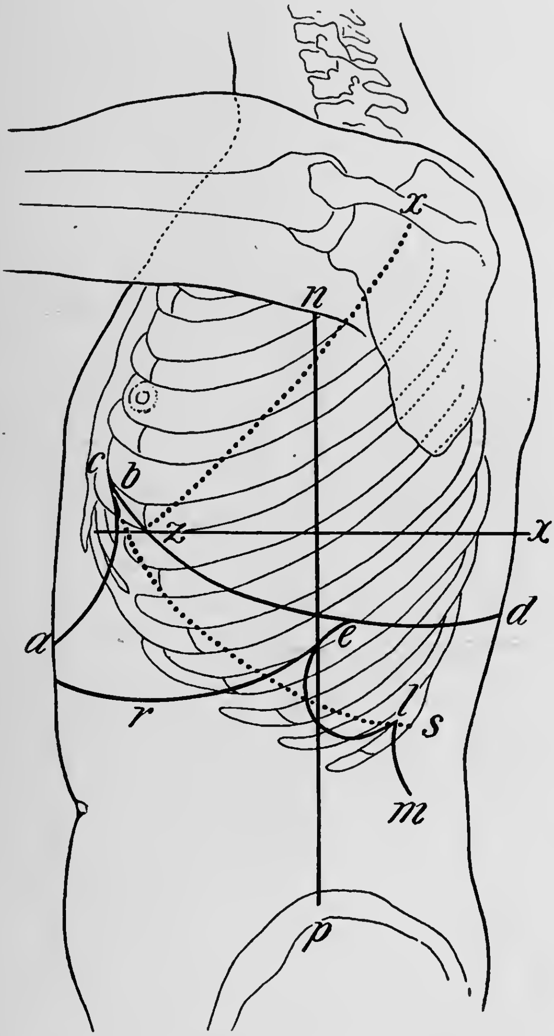


The horizontal line indicates the regional division of the lateral aspect of the chest: *ab*, lower boundary of right lung; *cd*, lower boundary of hepatic flatness; *ef*, upper boundary of hepatic dulness; *k*, border of kidney: *gb*, lower limit of expansion of lung; *xz*, fissure between posterior or lower lobe and the upper and middle lobes in front; *my*, fissure between the upper and middle lobes; *np*, is the right midaxillary line.

region is the space between the posterior margin of the scapula and the spinal column.

Laterally there are two regions, namely, the axillary

Fig. 4



ab, boundary of hepatic flatness; *cd*, lower boundary of the left lung; *e*, *l*, boundaries of spleen; *lm*, boundary of kidney; *r*, lower boundary of the stomach in moderate distention: *np*, left midaxillary line; *xz*, left interlobar fissure; *cs*, lower limit of expansion of lung.

and the infra-axillary. The axillary region is the space above a horizontal line extending from the lower border of the mammary region, *i. e.*, the sixth rib. The infra-axillary region is the portion below the axillary region.

The portion of the anterior surface occupied by the sternum is divided into the upper and the lower sternal region, the space above the sternal notch being the supra-sternal region.

In order to become familiar with the foregoing regional divisions, it is recommended to the student to delineate them with a skin pencil on the chest of the living subject or a cadaver (Figs. 1, 2, 3, 4).

It is advisable to study sections, extending from the surface to the centre of the chest, corresponding to the different regions, so as to become familiar with the relation of each section to the parts contained within it. An enumeration of the more important of the anatomical relations of the different regions is as follows:

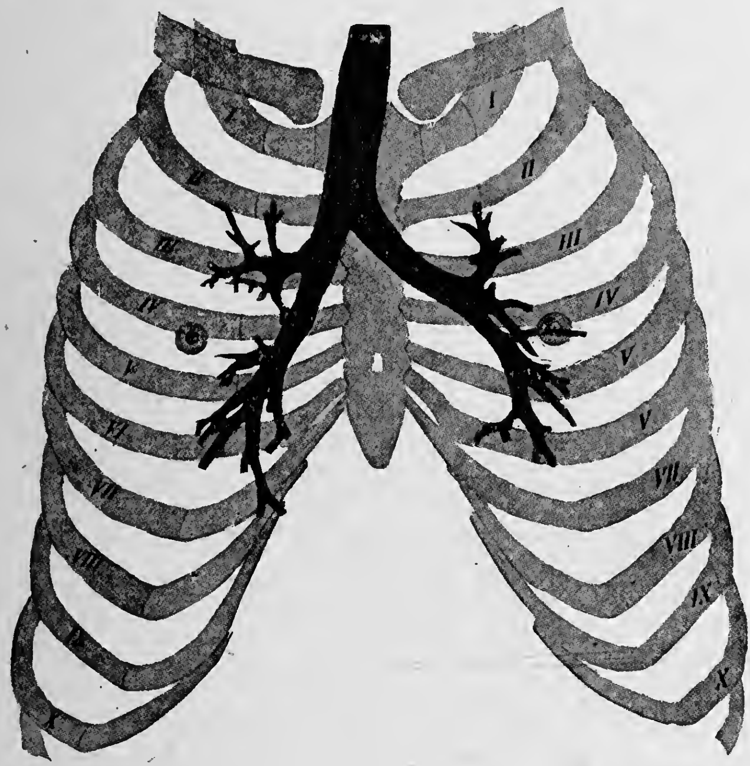
1. **Supra-clavicular Region.**—This is relative to the upper extremity or apex of the lung, which arises above the clavicle in different persons from half an inch to an inch and a half. The height is generally greater on one side, and this side is usually the left.

2. **Clavicular Region.**—A small portion of the lung at or near the apex is contained in the section corresponding to this region.

3. **Infra-clavicular Region.**—The parts situated here, exclusive of the upper sternal region (*vide* No. 7), are the upper portion of the lung, and the extra-

pulmonary bronchi. The difference between the primary bronchi, as regards direction, size, and length, are important points in the study of this section (Figs. 5, 6).

Fig. 5

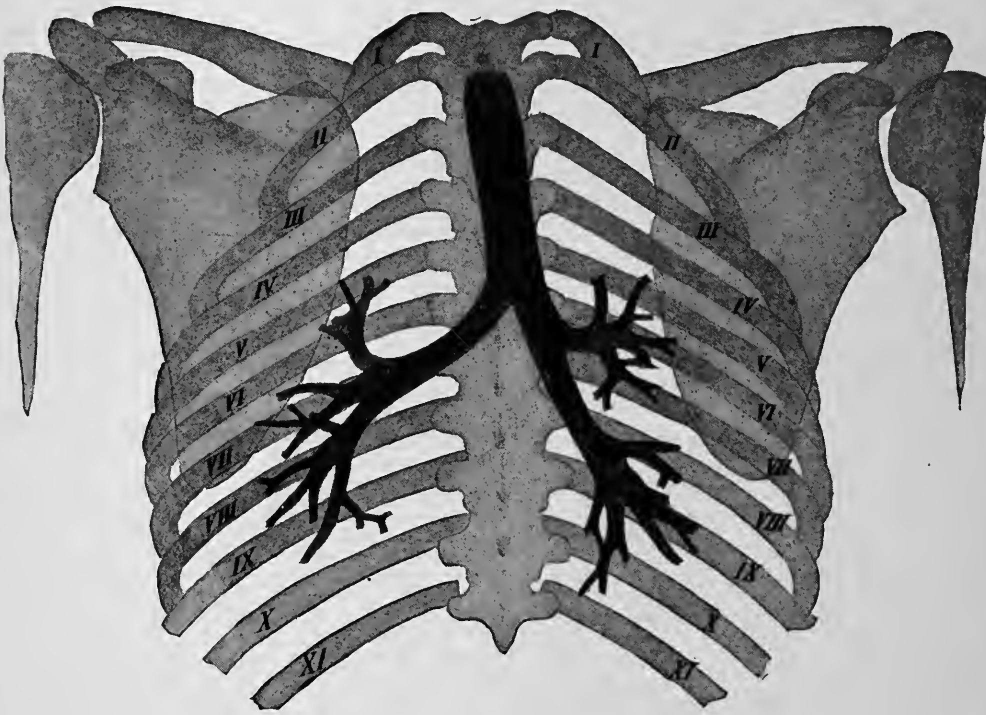


Position of the trachea, main and proximal subdivisions of the bronchi in relation to the ribs and sternum.

4. **Mammary Region.**—The differences between the two sides in the sections corresponding to this region are important. These differences relate especially to the precordia, and are involved in the physical diagnosis of enlargement of the heart. The commencement of the interlobar fissures is in this region. On the left side the fissure is between the fourth and fifth

ribs. On the right side the fissure between the upper and middle lobes begins at the fourth costal cartilage, and between the middle and lower lobes a short distance below. The situation of the fissures, however, differs considerably during the acts of inspiration and expiration. The liver reaches the fifth rib on the right side.

Fig. 6



Position of the trachea, main and proximal divisions of the bronchi in relation to the ribs and vertebral column.

5. **Infra-mammary Region.**—This region differs in its anatomical relations considerably on the two sides of the chest. On the right side the liver pushes upward the diaphragm nearly or quite to the upper boundary of the fifth rib. On the left side the section corre-

sponding to the region embraces, together with the anterior portion of the lower lobes of the lung, portions of the stomach, spleen, and the left lobe of the liver. The variable volume of the stomach at different times occasions considerable variations in the relative spaces occupied by these different parts.

6. **Supra-sternal Region.**—This region is in relation to the trachea.

7. **The Upper Sternal Region.**—The bifurcation of the trachea is beneath the sternum at the centre of a line connecting the second ribs. Below this line the lungs on the two sides are nearly in contact at the mesial line, covering the primary bronchi.

8. **Lower Sternal Region.**—The sternum in this region covers a large portion of the right and a little of the left ventricle, lying behind the right in this region.

9. **Scapular Region.**—The sections corresponding to this region contain the posterior portion of the upper lobe and a portion of the upper part of the lower lobe of the lung. At the upper part of the lower scapular space terminates the fissure separating the upper from the lower lobe. The line of this fissure pursues an oblique course to the fourth or fifth rib on the anterior aspect of the chest.

10. **Infra-scapular Region.**—On the right side the lung extends from the upper boundary of this region to the eleventh rib, the liver lying in contact with the chest-wall up to the latter point. On the left side the section contains a portion of the spleen.

11. **Inter-scapular Region.**—The trachea extends in this section to the fourth dorsal vertebra, where it

bifurcates.[1] Below this point on the two sides are situated the primary bronchi.

12. **Axillary Region.**—The section corresponding to this region contains a portion of the upper lobe with large bronchial tubes.

13. **Infra-axillary Region.**—This is in relation to the upper part of the liver on the right side, and on the left side to a portion of the spleen and stomach. The remainder of the section is occupied by lung.

It is recommended to the student to become familiar with the sections corresponding to the different regions, by dissections for this purpose, and the study of anatomical illustrations (Figs. 1, 2, 3, 4).

Asking the student's careful attention to the introductory considerations which have been presented, auscultation and percussion in health and disease, and the physical signs involved in the diagnosis of diseases of the respiratory system and of the heart, will now be considered.

[1] The position of the trachea and bronchi in relation to the bony points of the thorax is probably more accurately indicated in the diagrams of Dr. Blake (Figs. 5 and 6) than in the text. Amer. Jour. Med. Sci., March, 1899.

CHAPTER II

PERCUSSION IN HEALTH

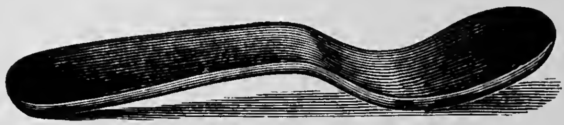
Percussion with the fingers or with a percussor and pleximeter —The normal vesicular resonance on percussion; its distinctive characters relating to intensity, pitch, and quality—Variations in the characters of the normal vesicular resonance in different persons—Relations of the pitch of resonance to the vesicular quality—Tympanitic resonance over the abdomen—Variations of the normal resonance in the different regions of the chest—Enumeration of the regions in which the resonance on the two sides varies, and those in which it is identical in health—Influence of age on the normal resonance—Influence of the acts of respiration on the resonance—Rules in the practice of percussion.

Percussion may be performed with either the fingers or artificial instruments. The fingers suffice for the study and in ordinary practice. Instruments are preferable only when it is desired to produce sounds to be heard at a distance, as in class illustrations, and when, from the number of patients to be percussed, as in dispensary or hospital practice, the frequent repetition of the blows renders the fingers tender and painful. The instruments are a pleximeter and a percussor. A good form of a pleximeter, and of a percussion hammer are illustrated in Figs. 7 and 8.

When percussion is performed with the finger, the palmar surface of one or more of those of the left hand should be applied to the chest, with pressure

sufficient to condense the soft structures, and the blows are given with one or more of the fingers of the right hand bent at the second phalangeal joint so as to form a right angle. In giving the blows, the movements should be limited to the wrist-joint, the ends, not the pulp of the percussing fingers being brought

Fig. 7



Pleximeter.

into contact with the dorsal surface of the finger or fingers applied to the chest. The percussing fingers should be withdrawn instantly the blow is given. The type of perfect percussion is the movement of the hammers when the keys of a piano-forte are struck.

Fig. 8

Percussion hammer.

The force of the percussion should never be sufficient to give pain to the patient; generally either light or moderately forcible blows suffice. The requisite tact in the performance of percussion is acquired by a little practice.

In percussing for the outlines of viscera lying close

to the chest-wall, light application of the pleximeter fingers, and a light stroke with the percussion finger gives best results.

In percussing for deeply situated margins of viscera or, for example, areas of consolidation or cavities, the pleximeter finger can with advantage be applied more firmly, and the percussion stroke be slightly more vigorous.

The first object in the study of percussion is to become acquainted with the characters which are distinctive of the sound obtained thereby from the healthy chest. For this object the percussion may be made either in the infra-clavicular region of either side, or in the infra-scapular region, the sound in these situations being louder than in other regions. Percussion being performed, a sound or resonance is produced. This sound or resonance is now to be analyzed with reference to characters derived from intensity, pitch, and quality. What are these characters? The intensity will depend, other things being equal, on the force of the blow; the resonance is comparatively feeble with a slight, and loud with a strong, percussion. Other circumstances affect the intensity irrespective of the force of the blow—namely, the volume of the lung, the elasticity of the costal cartilages, and the thickness of the soft parts which cover the chest. Owing to these circumstances, the intensity of the resonance is by no means similar, in the same situation, in all healthy persons; it is comparatively feeble in some and loud in others. There is nothing distinctive of this normal resonance to be derived

from intensity, and we say, therefore, that the intensity is variable.

What is the pitch of this normal resonance? The pitch of a sound is always relative; and, comparing this resonance with all the morbid signs obtained by percussion, it is lower in pitch. We say, therefore, that the pitch of this normal resonance is low. The pitch, however, is found to vary in different healthy persons.

What is the quality of this normal resonance? It has a quality which is peculiar to it. In this respect it is not identical with any sound produced otherwise than by percussion over healthy lung either within or without the chest. The quality cannot, therefore, be learned by analogy, nor can it be described; it can only be appreciated by direct observation. The peculiar quality is due to the fact that the resonance is from air contained in the pulmonary vesicles. This arrangement causes the peculiar quality, just as the construction of any particular musical instrument causes the quality of tone peculiar to the instrument; hence, as it is convenient to give the quality a name, we call it the *vesicular quality*. This quality is not equally marked in all healthy persons, being, as a rule, more marked in proportion to the intensity of the resonance.

This vesicular quality, as just noted, is peculiar to the pulmonary resonance. An approximative representation of it is obtained by percussing either a sponge or a loaf of bread. The latter gives a closer imitation than the former. Each of these articles

affords a resemblance to the vesicular quality of resonance, for the reason that it contains air in an infinite number of small spaces, in this regard resembling the lungs. In order to represent this sign by percussing a loaf of bread, the loaf should be covered with a napkin, in order to lessen the noise produced by the contact of the finger or the percussor, and thus to elicit better resonance from the air contained in the interstices of the loaf. The upper crust stands in place of the thoracic wall. The resonance elicited illustrates the lowness of pitch with a pretty close approach to the peculiar quality of the normal vesicular resonance.

The normal resonance, then, obtained by percussion may be thus defined:

A resonance of variable intensity, low in pitch and having a peculiar quality called vesicular. The word vesicular is frequently embraced in the name of this healthy sign; it is also called the normal resonance, the normal pulmonary resonance, or the normal vesicular resonance. The last of those names is to be preferred.

The normal vesicular resonance on percussion, as has been seen, is not uniform in all healthy persons; not only is its intensity variable, but it varies in pitch and in the amount of vesicular quality. This may be easily illustrated by percussing successively in the same situation, and with the same force, a series of persons who are assumed to be free from disease. Is there not in this fact an obstacle in practically determining this healthy sign? The fact occasions no embarrassment for this reason: we determine, in each case, that the resonance is normal by a com-

parison of the two sides of the chest, percussing in corresponding situations on the two sides and with the same force. There is no ideal standard of the normal vesicular resonance, but, by comparing the two sides of the chest, the standard of health proper to each person is obtained. The laws of disease are such that, for all practical purposes, the standard of health is in this way almost always available. Notwithstanding the variations within the range of health, the lowness in pitch and the vesicular quality are sufficiently distinctive of this normal sign as compared with the morbid signs.

The pitch of the vesicular resonance and its vesicular quality are in a uniform relation to each other; that is, the conditions giving rise to the peculiar quality also render the pitch low. In proportion as the vesicular quality is marked, the pitch is lowered, and, conversely, with diminution of the vesicular quality the pitch is relatively higher. This relation between the pitch and quality will be found to hold good in the resonance modified by disease as well as in health. Another relation may be here stated—namely, whenever, in health or disease, a tympanitic quality is combined with the vesicular, and in proportion as the former predominates, the pitch of the resonance is raised.[1]

[1] That the pitch of tympanitic resonance is invariably higher than the pitch of vesicular resonance, cannot be accepted, in view of the fact that relaxed sheep or calf lung, outside the body, will give a lower note than the same lung when moderately distended with air; and of this fact the student may easily convince himself.—Ed.

The pitch and quality of the normal vesicular resonance may be readily illustrated by percussing successively over the chest and the abdomen. The different sections of the alimentary canal generally containing more or less gas, a resonance is obtained by percussion over the abdomen. This resonance is, of course, devoid of the vesicular quality; in contradistinction to the latter, its quality is called tympanitic. This tympanitic resonance is not uniform in all parts of the abdomen, but everywhere the quality is tympanitic, that is, non-vesicular, and the pitch is everywhere higher than that of the normal vesicular resonance. The tympanitic resonance over the stomach is generally high in pitch, and frequently has a ringing or metallic intonation. The gastric tympanitic resonance recognized by these characters, will be found to be involved frequently in sounds produced by percussing over the chest. Gas in the cecum gives a still higher pitch of resonance. Ove the colon the resonance is lower than over the cecum and stomach, and it is still lower over the small intestines. In all these situations, bringing the tympanitic in contrast with the normal vesicular resonance, the peculiar quality of the latter and its lowness of pitch are rendered apparent. The term tympanitic resonance will be found to enter into the names of two of the morbid signs obtained by percussion.

Having studied the characters of the normal vesicular resonance, and become practically familiar with them by percussing different healthy persons, the student should study the variations which this

resonance presents in the different regions of the chest. In doing this he acquires more and more tact in the performance of percussion, and becomes more and more familiar with the characters in general of the normal vesicular resonance.

Supra- or Post-clavicular Region.—The resonance here varies much in intensity in different persons. The vesicular quality is most marked in the central portions. Toward the sternal extremity the resonance acquires a tympanitic quality from the proximity to the trachea; it becomes vesiculo-tympanitic, a term which will be applied to one of the morbid signs. In the supra-clavicular region resonance is to be found extending from three-fourths to two inches above the upper border of the clavicle.

Clavicular Region.—Near the sternum the resonance is somewhat tympanitic from the proximity to the trachea. At the central portion the vesicular quality is more or less marked, and the intensity is diminished at the acromial extremity.

Infra-clavicular Region.—The resonance in this region is more intense than elsewhere, except in the axillary and the infra-scapular regions. The vesicular quality is combined with a tympanitic quality toward the sternum, the latter being derived from the primary and secondary bronchi. As always when the vesicular and the tympanitic quality are combined, the pitch is raised. This combination in health and disease is recognized by the intensity, pitch, and quality.

Scapular Region.—The resonance in this region is notably less intense than in the infra-clavicular region,

owing to the presence of the scapula and its muscles. In proportion as the intensity is less, the vesicular quality is less marked. The resonance in health, however, is quite sufficient for morbid signs to be available in this situation. In the supra-scapular region resonance is to be found for a distance of two to three and a quarter inches along the upper border of the trapezius muscle.

Inter-scapular Region.—The resonance in this region is weak in comparison with other regions, except the scapular, owing to the muscles which here cover the chest. In the upper part of the region the resonance is somewhat tympanitic from the relation to the trachea and bronchi.

Mammary Region.—The right and the left mammary region are to be studied with reference to differences relating to the liver and the heart. On the right side, from the fourth rib downward, the resonance is diminished, the dome or upper surface of the liver extending up to this height. At or a little below the lower border of this region on the mid-clavicular line, that is, a vertical line passing through the middle of the clavicle, resonance ceases, the lower lobe of the right lung not extending below this point. Between the third and fifth ribs on this side near the sternum the resonance is diminished from the presence of a portion of the right auricle and ventricle. On the left side the resonance is dininished within the precordial space. This space extends vertically from the third rib to the fifth intercostal space, and horizontally from the sternum to a point at or a little

within the mid-clavicular line. The resonance is considerably diminished within what is called the superficial cardiac space. This space may be represented by a right-angled triangle, the right angle formed by a vertical line drawn from a point on the median line intersected by a horizontal line connecting the fourth ribs, and a horizontal line intersecting the point of apex-beat in the fifth intercostal space; an oblique line drawn from the centre of the sternum on a level with the fourth rib and the point of apex-beat forms the hypotenuse of the right-angled triangle. This oblique line is, in fact, a curved, not a straight, line (*vide* Fig. 1, p. 41), the convexity looking to the left side. Practically, however, it is near enough to accuracy to consider it the hypotenuse of a right-angled triangle. Within this space the heart is in contact with the thoracic wall. Without this space and within the precordia the heart is covered with lung, and the resonance on percussion is less diminished. It is a useful exercise for the student to observe the diminution of the area of the superficial cardiac space by a forced inspiration, as determined by percussion. Aside from the presence of the heart and the convex extremity of the liver, the resonance over the mammary is less than in the infra-clavicular region, being diminished by the pectoral muscle, which varies considerably in bulk in different persons, and in women by the mammary gland, the size of the latter varying very much in different women. The development of the mammæ, however, is never so great as to preclude the useful employment of percussion in this region.

Infra-mammary Region.—In this region, as in the region above it, the two sides present notable differences owing to the situation of the organs below the diaphragm. On the right side, over the greater part, and sometimes the whole of this region, resonance is wanting, that is, percussion gives flatness. It is easy to delineate the boundary between the lower border of the right lung and the liver, or, as it is called, *the line of hepatic flatness.* It is also easy to distinguish above this line the height to which the upper surface of the liver extends, or, as it is called, *the line of hepatic dulness.*[1] The situation of both these lines varies considerable in different healthy persons. The distance between the two lines is from one to two inches. Both lines are affected considerably by a forced inspiration and a forced expiration. A forced inspiration depresses the line of flatness about one and one-half inch. A forced expiration causes the line to rise from two and one-half to five and one-half inches. The distance, therefore, between this line at the end of a forced expiration and at the end of a forced inspiration varies from four to seven inches. With reference to the practice of percussion, as well as for the purpose of verification, these points should be studied. Not infrequently percussion over the right infra-mammary region yields a tympanitic resonance due to the distention with gas of the transverse colon.

[1] It is apparent, from the use of the *x*-ray in physical examination, that neither the accuracy nor the value of the line of hepatic dulness is such as to justify attempts at its determination by percussion. The lung-liver boundary and the liver edge are easily determined and of decided value.—Ed.

On the left side, the resonance in this region varies in different persons, in the same persons at different times, and in different portions of the region at the same time, the variations depending on the organs below the diaphragm. Flatness is caused by the extension of the left lobe of the liver into this region about three inches to the left of the median line. The left portion of the region is in relation to the spleen, an organ which varies considerably in size in health as well as in disease, its average dimensions being about four inches in length and three inches in width. Between the spleen and the liver lies the stomach, the volume of which is constantly fluctuating, owing to its varying solid, liquid, and gaseous contents. Distention of the stomach with gas occasions a tympanitic resonance which frequently is transmitted above into the mammary region in health as well as in disease. The space corresponding to the spleen is determined by the vesicular resonance above and the tympanitic resonance below, the latter boundary, however, not being very reliable on account of the ready conduction of tympanitic resonance for a certain distance.

The spleen lies in the left hypochondrium between the ninth and eleventh ribs, its long axis corresponding to the tenth rib. Its posterior extremity is about one and one-half inches from the spinal column; its anterior pole reaches to the middle or at most to the anterior axillary line.

The upper posterior third, being covered by lung is inaccessible to percussion.

The remainder, lying against the chest wall, unless forced away by intervening intestines, is found to give a dulness on examination in sitting, standing, or right and oblique recumbent position. The lung border, intersecting the eighth and ninth ribs, is the upper limit of splenic dulness; the anterior limit is rarely as far forward as the anterior axillary line; the lower limit is at the eleventh rib; posteriorly the dulness merges into that of the lumbar muscles.

Between the anterior splenic dulness and the left end of liver dulness is a half-moon shaped space (Traube's space) of tympany, which is of importance in the diagnosis of left-sided pleural exudates.

The distention of the stomach with solid or liquid contents, of course, occasions flatness. The study of the infra-mammary regions with reference to the variations in resonance arising from the relations to the organs below the diaphragm is of much utility from the practice, as well as the knowledge, which it involves. The exercise of endeavoring to define the boundaries of these different organs in healthy persons will be of great service to the student in acquiring tact in percussion, and in discriminating differences in the sounds obtained by this method.

Sternal Regions.—In the upper sternal region, that is, above the lower margin of the second rib, the resonance is non-vesicular, being derived from air in the trachea above the point of bifurcation. Being non-vesicular, it is, of course, tympanitic, inasmuch as the resonance is always tympanitic in quality if wholly devoid of the vesicular quality. Between

the second and third ribs, the inner borders of the two lungs approximating, the resonance has a vesicular quality more or less marked; but owing to the remnant of the thymus gland, together with adipose substance, and the presence of the large vessels, the resonance is not intense in this situation. Below the third rib the resonance has modifications, due to the combination of several different organs situated beneath the lower sternal region. On the right side of the mesial line is the inner border of the right lung, the greater part of the right and a portion of the left ventricle of the heart lying beneath; a portion of the liver extends into the lower part of this region, and a portion of the stomach when distended. The resonance thus varies in different situations, and often presents a mixed character. It is a useful exercise to endeavor to define by percussion the boundaries of the several organs which are here in juxtaposition. The bone of the sternum has a characteristic note of its own which modifies all percussion sounds obtained upon it, whether there be resonance or extreme dulness.

Infra-scapular Regions.—The resonance below the scapula is intense as compared with that over the scapula, and the vesicular quality is marked. The resonance extends to the eleventh rib, which is the lower boundary of the lung. On the right side, at or near this point, is the line of hepatic flatness, hepatic dulness extending from one to two inches above this line. The line of hepatic flatness and of hepatic dulness is lowered from one to two inches by a deep

inspiration, and raised by a forced expiration. On the left side the resonance may receive a tympanitic quality from the presence of gas in the stomach.

Lateral Regions.—In these regions the resonance is relatively intense, and notably vesicular. On the right side the line of hepatic flatness is at the eighth rib, hepatic dulness extending above this line, as in front and behind. On the left side the resonance may be rendered somewhat dull by the presence of the spleen, but it often has a tympanitic quality from the presence of gas in the stomach.

As has been stated, the normal vesicular resonance is not in all persons identical as regards intensity, pitch, and quality. There is, therefore, no fixed standard in these respects by which we can determine whether the resonance be normal or not. The standard proper to each person is to be ascertained by a comparison of the two sides of the chest; each person, in other words, furnishes his own standard of health. But it is to be observed that all the regions do not normally correspond in respect of the resonance on the two sides. In the following regions the resonance is notably dissimilar on the two sides: The mammary, the infra-mammary, the infra-axillary, and the infra-scapular. There is less disparity in the resonance on the two sides in the following regions: The supra-clavicular, clavicular, and infra-clavicular, the scapular and inter-scapular, and the axillary. In some of these regions, however, the resonance differs, and it is of practical importance to note the dissimilarity which thus belongs to health. This

statement applies especially to the infra-clavicular region, a region which, as will be seen hereafter, is of great importance with reference to the signs of phthisis. In this region the resonance on the left side is somewhat more intense, more vesicular, and lower in pitch than is the resonance on the right side; *per contra,* the resonance is less intense, less vesicular, and higher on the right side. This account of these points of disparity between the two sides is based on an analogy of recorded observations in a series of healthy persons.[1] The student should become practically familiar with the normal differences between the two sides, and, in becoming so, the practical experience acquired in performing percussion will be of use.

The normal resonance is affected by age. In early life, when the costal cartilages are flexible and elastic, the resonance is more intense and lower in pitch than in old age, when the cartilages are rigid and the vesicular structure of the lung more or less atrophied.

The resonance varies considerably in the different regions at the end of a full inspiration and at the end of a forced expiration. With regard to this disparity, the following is an extract from a work on physical exploration, published by the author in 1856:

"The percussion sound may also be found to vary at different periods of an act of respiration in the same individual. The quantity of air contained within the air-cells, and consequently the relative

[1] *Vide* Physical Exploration of the Chest by the Author, 1856.

proportion of air and solids, are by no means equal after a full inspiration and after a forced expiration. The difference in lung expansion may occasion an appreciable disparity in resonance, according as the percussion is made at the conclusion of a full inspiration or of a forced expiration. The disparity is not appreciable uniformly in different persons. This fact I have ascertained by noting the results of examinations made with reference to the point. When it does exist, it usually consists, contrary to what might perhaps have been anticipated, and the reverse of what is usually stated in works on physical exploration, in diminished resonance and elevation of pitch at the conclusion of inspiration. This is probably to be explained by the greater degree of tension of the lungs and thoracic walls produced by inspiration voluntarily prolonged and maintained—a condition presenting physical obstacles to sonorous vibrations more than sufficient to counterbalance the increased proportion of air within the cells. It is a curious fact, worthy of notice, that the two sides of the chest are not always found to be affected equally as regards the percussion sound, at the conclusion of a full inspiration, contrasted with that after a forced expiration. I have observed the contrast to be more striking on the right than on the left side; and in one instance on the left side, the resonance was less intense and somewhat tympanitic after a full inspiration, while on the right side the opposite effect was produced and the sound became quite dull after a forced expiration. In view of these variations in a certain propor-

tion of instances incident to different periods of a single act of respiration, in some cases of disease in which it is desirable to observe great delicacy in the correspondence of the two sides, pains should be taken to percuss corresponding points at a similar stage of respiration, and the close of a full inspiration is, perhaps, the period to be preferred. Ordinarily, the liability to error from this source is obviated, either by repeating a series of strokes, first on one side and next on the other, or by percussing both sides repeatedly in quick succession, in order mentally to obtain the average intensity and other characters of the sound during the successive stages of a respiration. The instances of disease, however, are exceedingly rare, in which such nicety of discrimination is important."

There are two variations in methods of percussion which are found to assist in determining the boundaries of solid viscera and cavities: *A*, the so-called auscultatory percussion, which consists in applying the stethoscope over an area to be outlined, as over the precordium, and then by light percussion (or even delicately stroking or scratching the skin), approaching the stethoscope from all directions, noting the sudden change in intensity of the conducted sound as the border of the underlying viscus is reached. This method is of service also in outlining the borders of the stomach; *B*, the so-called threshold percussion of Goldscheider which consists in light percussion upon the second phalangeal joint of the bent pleximeter finger, the tip only of the finger being applied to the chest. By using only the interspaces and also

limiting as finely as this the point of application of the stroke, often very precise limits of the heart may be determined.

RULES IN THE PRACTICE OF PERCUSSION

1. Prior to a comparison of the two sides of the chest, as regards the resonance on percussion, either in health or disease, an examination by inspection should be made, in order to determine whether there be any deviation from the normal conformation. In what has been stated concerning percussion in health, it is assumed that the chest is symmetrical. Want of symmetry may be due to congenital deformities, and to those caused by rachitis, chronic pleurisy, curvature of the spine, and injuries. Any deviation from the normal conformation will affect more or less the resonance in corresponding regions on the two sides. Due allowance is to be made for want of symmetry in determining morbid signs, and often the existence of these cannot be determined with positiveness when there is considerable deformity. The signs obtained by auscultation are less affected by want of symmetry than those obtained by percussion.

2. Attention to the position of the person examined is important with reference to the normal symmetry of the chest. If the person be standing or sitting, the position should be upright and the shoulders brought to a level. A little inclination of the body

to one side, or a depression of one shoulder, will be found to affect perceptibly the normal resonance when the two sides are compared. If the body be recumbent, it should be as nearly as possible on a level plane. In examining a patient in the lateral recumbent position, the side which is uppermost should be examined and the patient turned then to the other side, for reliable comparison between the two sides in percussion and auscultation cannot otherwise be made. These conditions are indispensable for a nice comparison of the two sides either in health or disease.

3. In making a nice comparison, the person who percusses should be, as nearly as possible, either in front or behind the person percussed. Percussion made by one standing or sitting by the side of the person percussed is almost certain to produce disparity in resonance.

4. Percussion made successively on one side and the other side, must be in all respects the same in regard to the mode, the force of the blow, and the situation. A light percussion on one side and a strong percussion on the other side will, of course, cause a disparity in the intensity of resonance. The percussion must be made in succession at points as nearly as possible equidistant from the median line, and from the summit or base of the chest. With reference to great nicety, the percussion, if made on the rib or intercostal space on one side, must be made

on the rib or intercostal space on the other side. Great nicety of comparison also requires that if the percussion be made on one side during the act of inspiration it should be made on the other side during this act. The signs of disease, however, are generally so well marked that very close attention to these points is not necessary.

5. A series of blows in rapid succession (five or seven) is to be preferred to one or two, in practising percussion, difference in intensity, pitch, and quality being thereby better appreciated.

6. Percussion may be made lightly or forcibly, the former being called superficial, and the latter, deep percussion. With light blows the resonance comes from the superficies of the lung and from within a limited area. With forcible blows the resonance is from a greater depth and a wider space. The result of these different modes of practising percussion may be illustrated within the precordia in health. Comparing the resonance over the superficial cardiac space with that in a corresponding situation on the right side, dulness is more marked with light than with forcible blows, the resonance from the latter coming from a wider area. On the other hand, comparing the resonance over the deep cardiac space, dulness is more marked with forcible than with light blows, owing to the presence of lung between the heart and the walls of the chest. This rule is of importance in its application to percussion in disease.

7. Percussion over the anterior portion of the chest, the person percussed leaning against a door, a board partition, or a lathed wall, gives an increased intensity of resonance. It is often useful to resort to this procedure in the practice of percussion.[1]

8. In percussing over the posterior portion of the chest it is important that the scapulæ be drawn forward and downward. By having the patient cross the arms upon the chest, the hands being placed upon the tips of the shoulders and then drawing the shoulders down and bending the head well down upon the chest, the greatest area of the posterior thorax is exposed to examination. Thus the supra-scapular and inter-scapular regions become artificially increased to the great convenience of the examiner. The above procedure is of value when the patient is standing or sitting up in bed.

A position which gives the maximum of muscular relaxation and the greatest exposure of the upper lobes behind may be assumed by the patient while seated on a stool: the body is bent well forward, the head hanging downward and forward upon the chest, and the arms hanging down loosely outside the thighs.

[1] This very intensity of resonance may lead to error if the patient is examined while lying on a couch which is equipped with a box-spring. Ignorance of, or inattention to, the resonating cavity beneath the patient may cause confusion in interpreting the signs of percussion.

CHAPTER III

PERCUSSION IN DISEASE

Enumeration of the signs of disease furnished by percussion —Requirements for a practical knowledge of these signs—The distinctive characters of the morbid physical conditions represented by, and the different diseases into the diagnosis of which enter the signs, severally, to wit: 1. Absence of resonance or flatness. 2. Diminished resonance. 3. Tympanitic resonance. 4. Vesiculo-tympanitic resonance. 5. Amphoric resonance. 6. Cracked-metal resonance. 7. Unusual changes of tone—Sense of resistance felt in the practice of percussion as a morbid sign.

PERCUSSION in cases of disease furnishes signs which represent morbid physical conditions incident to the different pulmonary affections; with these physical conditions and their relations to pulmonary affections the student is supposed to be familiar (*vide* page 25 *et seq.*).

The signs of disease furnished by percussion are resolvable into six, namely: 1. Absence of resonance or flatness. 2. Diminished resonance or dulness. 3. Tympanitic resonance. 4. Vesiculo-tympanitic resonance. 5. Amphoric resonance. 6. Cracked-metal resonance. The two last named signs are properly varieties of tympanitic resonance, but it is most convenient to consider them as distinct signs.

Knowledge of these six signs sufficient for their availability in physical diagnosis requires, *first,* a

practical acquaintance with the characters which distinguish each from the others, as well as from the normal resonance; and *second,* a clear apprehension of the significance of each, that is, the morbid physical conditions which they severally represent. Under these two aspects the signs will now be considered.

1. ABSENCE OF RESONANCE OR FLATNESS

This sign is sufficiently defined by its name. It is absence of resonance or tone. Nothing is heard but a noise such as may be produced by percussing over a solid mass, for example, a limb composed of muscle and bone, or over a collection of liquid, for example, the abdomen in hydro-peritoneum or ascites. There being no resonance or tone, the sign has no characters pertaining to pitch or quality. It may be illustrated on the healthy chest by percussing in the right infra-mammary region below the line of hepatic flatness.

There are four classes of morbid physical conditions giving rise to flatness on percussion—namely, (1) the presence of liquid either in the pleural sac or in pulmonary cavities; (2) liquid filling the air-vesicles; (3) complete solidification of lung; and (4) a tumor within the chest.

Flatness on percussion always represents one of these morbid physical conditions. Extreme thickening of the visceral and parietal pleura at the base of the lung may give a note so nearly flat that a differ-

ential diagnosis cannot be made between thickened pleura and hydrothorax without the use of an exploring needle.

These conditions are incident to different diseases, as follows:

(1) Liquid in the pleural cavity is incident to pleurisy with effusion, empyema, and hydrothorax. A collection of pus constitutes pulmonary abscess, and phthisical cavities, or those caused by circumscribed gangrene, may become filled with morbid liquid products.

(2) Serous effusion into the air-vesicles constitutes pulmonary edema. Liquid blood extravasated characterizes hemorrhagic infarctus, pneumorrhagia, or pulmonary apoplexy. Pus infiltrating more or less of the parenchyma may be derived from an abscess either within the lung or elsewhere, for example, the liver, and from the pleural cavity in empyema when perforation of lung takes place.

(3) Solidification of lung occurs in pneumonia from an exudation within the air-cells; it is produced by condensation from compression by liquid or air in the pleural sac, the pressure of a tumor, and by collapse; it exists in cases of phthisis, in interstitial pneumonia, and in neoplastic infiltration of lung.

(4) Tumors within the chest are of different kinds, for example, aneurisms, primary and secondary neoplasms, and teratomata. In proportion to their size they occupy space belonging to the lung, as well as condensing the latter by pressure. Flatness may also be caused by the encroachment of organs situated

below the diaphragm upon the thoracic space, as in cases of enlargement of the liver and spleen, and in massive ascites.

Flatness on percussion in all these conditions is the same. The sign alone does not enable us to discriminate the conditions from each other, nor to determine the existing disease.

Finding this sign present, the particular condition and the disease in each case are to be determined by the situation of the flatness, its extent, the associated physical signs furnished by auscultation, together with the other methods of exploration, and by the symptomatic phenomena.

2. DIMINISHED RESONANCE OR DULNESS

The resonance on percussion is diminished, or there is dulness, when the solids or liquids within the chest are morbidly increased without increase in the quantity of air, the increased amount of solids or liquids not being sufficient to cause flatness. Diminution of air without increase of either solids or liquids, as in collapse of pulmonary lobules, also gives rise to dulness. We may formularize the physical conditions by saying, that they consist in an abnormal proportion of solids or liquids over the air in the pulmonary vesicles.

Dulness varies in degree. It may be slight, moderate, considerable, or great. These adjectives of quantity express sufficiently the variations in this regard. The degree of dulness corresponds to the

amount of the relative disproportion of solids or liquids over the air within the chest.

The pitch of sound is higher than that of the normal resonance of the persons percussed. This is invariable; with dulness there is always more or less elevation of pitch. The quality is altered only in amount; there is, of course, less vesicular quality in proportion as the intensity of the resonance is diminished.

The characters which distinguish this sign, thus, are, lessened intensity of resonance, elevation of pitch, and weakened vesicular quality.

The morbid conditions giving rise to this sign are those which, existing in a greater degree, give rise to flatness. Morbid products within the pleural sac, fibrin, serum, pus, lymph, if not sufficient to cause flatness, give rise to dulness. The sign, therefore, occurs in pleurisy, empyema, and hydrothorax. The same is true of pulmonary edema, hemorrhagic infarctus, pneumorrhagia, and purulent infiltration of lung. Solidification of lung, when not complete, occasions dulness; hence, it is a sign in pneumonia, vesicular and interstitial, in phthisis, in condensation of lung from compression, in collapse of pulmonary lobules, and in neoplastic infiltration. A tumor within the chest, not sufficiently large to cause flatness, gives rise to dulness.

There are, however, some conditions giving rise to dulness, which are never sufficient to cause flatness. Pulmonary congestion limited to a lobe may diminish the resonance appreciably. The dulness may exist in the first stage of pneumonia, before solidification

from pneumonic exudation has taken place. A layer of lymph upon the pleural surfaces causes dulness after the liquid effusion in pleurisy has been removed, and after the vesicular exudation in pneumonia is absorbed. Dulness may also be caused by a considerable accumulation of mucus or coagulated blood within the intra-pulmonary bronchial tubes.

The particular morbid condition which gives rise to dulness cannot be inferred from the characters of the sign: the sign only denotes that some one of the different morbid conditions exists. The condition which exists in each case, and the disease, are to be determined by the situation, extent, and degree of dulness, taken in connection with the information derived from other methods of exploration than percussion, together with the history and symptoms.

3. TYMPANITIC RESONANCE

Resonance is tympanitic whenever it is entirely devoid of the vesicular quality; in other words, any resonance which is non-vesicular is tympanitic. The leading distinctive character of the preceding sign (dulness) relates to intensity, whereas, the leading distinctive character of this sign relates to quality. Tympanitic resonance derives no distinctive character from intensity; it may be either more or less intense than the resonance of health in the person percussed. This point is to be emphasized, inasmuch as with many the idea of tympanitic resonance involves

increased intensity of sound; a resonance, be it ever so feeble, if it be non-vesicular, is tympanitic. If, however, the resonance be quite feeble, it is not always easy to determine whether there be, or be not, any appreciable vesicular quality. The term used by Stokes, namely, "tympanitic dulness," is properly enough applied to a resonance with diminished intensity, in which a vesicular quality cannot be appreciated. As regards pitch, a tympanitic resonance is higher than the normal vesicular resonance. If there be any exceptions to this rule, they are extremely infrequent. The tympanitic resonance over different parts of the abdomen is always higher in pitch than the resonance over healthy lung.

The following are the morbid physical conditions which give rise to the tympanitic resonance:

(1) Air in the pleural cavity. It is, therefore, a sign of pneumothorax. Frequently in this affection the tympanitic resonance is more intense than the resonance of health, the pitch being always more or less raised.

(2) Pulmonary cavities containing air. It occurs, therefore, in cases of phthisis. In this disease the tympanitic resonance is limited to a circumscribed space corresponding to the site and size of the cavity, whereas, in pneumothorax, it frequently exists over a considerable part, or the whole, of the affected side of the chest.

(3) Complete solidification of the whole or a part of the upper lobe of lung. The tympanitic resonance under these circumstances must be derived

from the air in the lower part of the trachea and the bronchial tubes exterior to the lungs. This is the explanation of the sign in the second stage of pneumonia affecting an upper lobe, and in certain cases of phthisis prior to the stage of excavation. Dilatation of the intra-pulmonary bronchial tubes, with solidification surrounding them, as in some cases of interstitial pneumonia or cirrhosis of lung, may give rise to tympanitic resonance.

(4) Conduction of resonance from the stomach or colon containing air or gas. A gastric tympanitic resonance is frequently conducted over a part, and sometimes over the whole, of the left side of the chest. This is more likely to occur when the left lung is solidified. On the right side less frequently a tympanitic resonance may be conducted upward from the colon to a greater or less extent.

Tympanitic resonance may be illustrated by percussion over the hollow abdominal viscera of the abdomen, provided they contain air or gas. The sign may be imitated by percussing an inflated bladder or India-rubber balls. The pitch will be found to vary according to the size and the degree of inflation of the bladder or balls. To illustrate this resonance in proximity to a vesicular resonance produced artificially, one-half of the soft portion of an oblong loaf of bread may be removed, leaving intact the upper crust. Percussion over this half of the loaf illustrates the tympanitic, and over the other half the vesicular, resonance.

4. VESICULO-TYMPANITIC RESONANCE

This name was proposed by the author many years ago to denote a sign with the following distinctive characters: The resonance increased in intensity; the quality a combination of the vesicular with a tympanitic, and the pitch high in proportion as the tympanitic quality predominates over the vesicular.

The sign represents especially one morbid physical condition, namely, an abnormal accumulation of air in consequence of dilatation of the air-vesicles, that is, pulmonary or vesicular emphysema. The sign also is present in interstitial or interlobular emphysema. The relation of the sign to these affections renders it of great value in physical diagnosis.

A vesiculo-tympanitic resonance is obtained when the pleural sac is partially filled with liquid, by percussing over the lung on the affected side. Although the pressure of the liquid diminishes the volume of the lung, as a rule, it yields this sign. The resonance is vesiculo-tympanitic above the liquid when the latter is sufficient to fill a third, a half, or even two-thirds of the intra-thoracic space. The sign is also obtained over the upper lobe when the lower lobe is solidified in the second stage of pneumonia, and over the lower lobe when the upper lobe is solidified.[1]

[1] The explanation given above for the mechanism or cause of vesiculo-tympanitic resonance does not at present meet with approval. It is altogether probable that it is not the abnormal accumulation of air, but the altered resilience, or diminished elastic tension of the pulmonary tissue which is responsible for the altered note.—Ed.

A loaf of bread may be used to illustrate a vesiculotympanitic resonance, as follows: By means of a hollow cylinder remove longitudinal sections in one-half of the loaf, leaving the crust intact. The spaces thus produced yield a tympanitic resonance, and the portions which surround these spaces give the vesicular resonance. The vesicular and the tympanitic quality are thus combined, with elevation of pitch and increased intensity; over the other half of the loaf the resonance is purely vesicular. Another method of illustrating this sign out of the body is to inflate the human lungs, or the lungs of the sheep or calf, considerably beyond the limit of a normal inspiration. Inflated beyond that limit the emphysematous condition is produced, and the resonance represents that condition.

5. AMPHORIC RESONANCE

Resonance is said to be amphoric when it has a musical intonation analogous to that produced by blowing over the mouth of an empty bottle. An amphoric sound is easily illustrated by filliping the cheek made tense, the mouth not completely closed, and the jaws separated, as is done when the sound of a liquid flowing from a bottle is imitated. By varying the size of the cavity of the mouth the amphoric sound thus produced may be made to vary much in pitch. This illustration exemplifies the mechanism of the sign in disease.

The sign represents a pulmonary cavity which is

generally phthisical. The conditions, aside from the existence of the cavity, are, rigidity of its walls, so that they do not collapse, the presence, of course, of air within the cavity, and free communications with the bronchial tubes. These accessory conditions are not constant, so that an amphoric resonance over a cavity is sometimes found, and at other times is wanting. Directly after having been wanting, it may be reproduced if the patient expectorate freely.

When percussion is made with reference to this sign, the mouth of the patient should be open, and one or two rather forcible blows are better than a series of four or six. The amphoric sound may be often distinctly perceived if the ear be brought into close proximity to the patient's open mouth, when the sign is not appreciable otherwise. It may be rendered still more distinct by means of the binaural stethoscope, the pectoral extremity being close to the mouth of the patient.

As a cavernous sign the amphoric resonance is very reliable; but it does not invariably denote a pulmonary cavity. It is obtained in some cases of pneumothorax, the pleural space filled with air forming a cavity, which communicates with the bronchial tubes through a perforation of the lung situated above the level of the liquid. It is sometimes obtained over a solidified portion of lung situated in close proximity to a primary bronchus, the resonance being derived from the air within the latter. It is occasionally produced by percussing over the site of the primary bronchus in the second stage of pneumonia affecting

an upper lobe. In children, owing to the yielding of the costal cartilages, it may even be produced in health over a primary bronchus. In all these exceptional instances the associated signs and symptoms will prevent the error of attributing the sign to a pulmonary cavity.

This sign is properly a variety of tympanitic resonance.

6. CRACKED-METAL RESONANCE

The name of this sign, expressing an analogy to the sound produced by striking a cracked metallic vessel, denotes its peculiar character. It may be imitated by folding the hands so as to form a cavity and striking them upon the knee, in the familiar trick of producing in this way a sound as if metal coins were betweem the palms. This illustration, also, exemplifies the mechanism of the sign. Like the sign last described, it is a variety of tympanitic resonance.

The cracked-metal, like the amphoric, resonance represents generally a phthisical cavity. Percussion is to be made in the same way as for the production of the amphoric resonance, and, like the latter, the cracked-metal character is often perceived if the ear, or, better still, the stethoscope be brought close to the patient's mouth when otherwise it is not appreciable.

The cracked-metal and the amphoric resonance are often associated; and the statements made with respect to the exceptional instances in which the latter is produced, without the existence of a pulmonary cavity, will apply equally to the former.

7. THE WINTRICH, WILLIAMS, AND GERHARDT PHENOMENA

If a patient who exhibits a *vesiculo-tympanitic* note or tympany over a cavity opens his mouth during percussion the pitch of the note is raised. This is called Wintrich's tone change or Wintrich's phenomenon. When this phenomenon occurs where there is infiltrated or contracted lung tissue but no cavity it is called Williams' tracheal tone. If the pitch of a tympanitic note over a cavity changes with the patient's position we speak of this change as Gerhardt's tone change or phenomenon. It indicates a change of the shape of the resonating chamber, owing to the shifting of fluid on change of position.

In addition to the acoustic phenomena produced by percussion with the fingers applied to the chest instead of a pleximeter, an abnormal *sense of resistance* is felt in certain conditions of disease. In health, with a somewhat forcible percussion, the walls of the chest are felt to yield in proportion as the costal cartilages are flexible. This yielding is diminished or ceases when a collection of liquid in the pleural cavity, or liquid in the air-vesicles, and solidification of lung, offer a mechanical obstacle thereto. An abnormal sense of resistance on percussion, thus determinable by comparison of the two sides of the chest, is a sign representing some one of the morbid physical conditions just named. This properly belongs among the signs obtained by palpation. The sign is to be taken in connection with other signs in determining the condition which exists in particular cases.

CHAPTER IV

AUSCULTATION IN HEALTH

Importance of the study of the auscultatory sounds in health—Immediate and mediate auscultation—Advantages of the binaural stethoscope—Rules to be observed in auscultation—Divisions of the study of auscultation in health—The normal laryngeal and tracheal respiration—The normal vesicular murmur; its distinctive characters, and the variations in the different regions on the same side, and in corresponding regions on the two sides of the chest—The normal vocal resonance—The laryngeal and tracheal voice and whisper—The normal thoracic vocal resonance and fremitus; the distinctive characters of each: the variations in different regions on the same side, and in corresponding regions on the two sides of the chest—The normal bronchial whisper, with its variations in different regions on the same side, and in corresponding regions on the two sides of the chest.

The term auscultation, limited in its application to the respiratory system, denotes the act of listening to the normal and abnormal sounds produced by respiration, voice, and cough. In this and the next chapter, the method of exploration thus named will be considered in its application to the respiratory system; it will be considered subsequently as applied to sounds relating to the circulatory system.

The study of auscultatory sounds in health is essential as preparatory for the study of auscultation in disease. The student must be familiar with

the normal sounds before undertaking to become acquainted with those which represent morbid conditions. Ample time and attention should be given to the study of auscultation in health. The omission to do this is a frequent cause of difficulty and want of success in attaining to a satisfactory proficiency in physical diagnosis. The practical skill required in diagnosis may be obtained in advance by devoting sufficient study to the healthy chest before entering on the study of the anscultatory signs of disease. Moreover, as will be seen, some of the most important of the morbid signs have their analogues in certain normal sounds pertaining to the respiratory system.

Auscultation is either immediate or mediate. It is immediate when the ear is applied directly to the chest, which may be either denuded or covered with a cloth or more or less of the clothing. It is mediate when the sounds are conducted to the ear by means of an instrument called a stethoscope. The student should practise both immediate and mediate auscultation. The direct application of the ear to the chest suffices for diagnosis in many cases of disease; but there are sometimes objections to this by the patient on the score of delicacy, and by the auscultator on the score of the uncleanliness of the person examined. There are certain parts of the chest which can only be explored by the stethoscope, and this instrument has the advantage of circumscribing the space whence the auscultatory sounds are derived. Moreover, by means of the stethoscope, which is to be preferred over

the great variety of instruments heretofore in use, the sounds are heard much better than by immediate auscultation.

Stethoscope.—The stethoscope which is to be preferred conducts the sounds into both ears, that is, it is binaural. In this consists its great superiority. An instrument must be very good, or it is without value. The knobs which are to enter the ears must be of the right size; if they enter too far they occasion pain. The curves at the aural extremity must be such that the aperture is in the direction of the meatus of the ear. The flexible tubes must not be stiff, and their movements must be noiseless. All the tubes must be unobstructed, for it is the air within the tubes which chiefly conducts the sounds. In the use of the instrument it should be applied to the chest without any intervening clothing.

The use of the binaural stethoscope is so universal and the types are, on the whole, so similar that it seems out of place in the present edition to discuss the matter in detail. The selection of the chest-piece, whether large or small, funnel or bell-shaped, is a matter for the individual physician to decide according to his need and use. The flat chest-piece used in the Bowles' phonendoscope is convenient in examining the posterior regions of the chest, in patients so ill in bed that the chest cannot be made easily accessible in all its parts.[1]

[1] The makes of stethoscopes provided by Tiemann and Ford, in New York, and the Gannett model used largely in Boston and Baltimore, are reliable. The Bowles' phonendoscope is made by Pilling & Sons, of Philadelphia.

Rules for Auscultation.—The rules to be observed in the practice of auscultation, in health and disease, may be here introduced.

In auscultation, as in percussion, corresponding situations on the two sides of the chest are to be explored successively, and compared. When the stethoscope is used, the pectoral extremity must be applied on each side with the same degree of pressure; this is especially essential in the comparison of vocal sounds. In immediate auscultation, the ear is to be applied with a certain degree of force, and a thin layer of clothing does not interfere materially with the perception of auscultatory sounds. The ear not applied to the chest may or may not be closed by the finger in listening to the respiratory sounds; it should be closed in listening to the vocal sounds, in order to prevent confusion from attention to the voice from the patient's mouth. In immediate auscultation, whenever practised, the auscultator should take a position which will not interfere with the sense of hearing, and not occasion a feeling of discomfort. These difficulties are in the way of auscultating with the body bent forward; the sense of hearing is dulled by the detention of blood in the head, and the position cannot be maintained without discomfort. The person examined, if practicable, should be sitting, and the position for the auscultator is that of kneeling on one knee, and lowering, if necessary, the body, so that the head may be kept upright. These points are less important if the binaural stethoscope be used.

When listening to respiratory sounds, it is gener-

ally desirable that the person examined should breathe with somewhat greater force than in ordinary breathing; but it is important that the normal rhythm of respiration should be unchanged. Persons when requested to breathe with increased force are apt to err in breathing violently, and sometimes too slowly. The readiest mode of obtaining what is desired, is for the examiner to illustrate it by his own breathing. A complete expiration is important in order to secure a satisfactory inspiration. It should, therefore, be made clear by explanation and illustration, that each expiration should be finished before the following inspiration.

The ability to abstract the mind from thoughts and other sounds than those to which the attention is to be directed, is essential to success in auscultation. All persons do not possess equally this ability, and herein is an explanation in part of the fact that all are not alike successful. To develop and cultivate by practice the power of concentration is an object which the student should keep in view. Generally, at first, complete stillness in the room is indispensable for the study of auscultatory sounds; with practice, however, in concentrating the attention, this becomes less and less essential.

The study of auscultation in health embraces the following:

1. The sounds produced by respiration as heard over the larynx and trachea, or the *normal laryngeal and tracheal respiration.*

2. The sounds heard over the chest in the acts of respiration. These sounds, coming chiefly from the air-vesicles, constitute what is called the *normal vesicular murmur.*

3. The resonance heard over the chest, and the vibration or thrill produced by the loud voice, or the *normal vocal resonance and fremitus.*

4. The sounds heard over the chest with the whispered voice, or, inasmuch as these sounds are conducted chiefly by the air in the bronchial tubes, the *normal bronchial whisper.*

These four normal signs will be considered in the foregoing order.

NORMAL LARYNGEAL AND TRACHEAL RESPIRATION

For all practical purposes the laryngeal and the tracheal respiration may be considered to be identical, that is, the shades of difference between the sounds in these two situations are not of importance as regards the application to physical diagnosis. The laryngeal respiration is more readily studied than the tracheal, and for the study of each the stethoscope is necessary.

Applying the stethoscope over the side of the larynx, the person examined breathing with some increase of force, but without any alteration in rhythm, a sound is heard with each of the two acts of respiration. The inspiratory and the expiratory sound, studied

separately and contrasted with each other, have the following characters relating to intensity, pitch, quality, duration, and rhythm: The inspiratory sound is of variable intensity. In ordinary breathing it varies much in different persons, and in different acts of breathing in the same person. It is always intensified in forced breathing. The pitch is high when compared with the inspiratory sound as heard over the chest. The quality of the sound is well defined by the word tubular; the sound at once suggests a current of air through a tube. The duration of the sound is from the beginning to nearly, not quite, the end of the inspiratory act. The characters of the inspiratory sound, thus, are more or less intensity, a high pitch, a tubular quality, and a duration a little less than that of the act of inspiration.

An expiratory sound is always heard with forced breathing. As regards duration, it is as long as, or longer than, the sound of inspiration. In general it is more intense than the sound of inspiration. The pitch is higher than that of the inspiratory sound. The quality is the same as that of the inspiratory sound, namely, tubular.

Repeating the characters distinctive of the normal laryngeal respiration, they are as follows: The inspiratory sound is of variable intensity, high in pitch, and tubular in quality. The expiratory sound is as long as, or longer than, the inspiratory sound; it is higher in pitch, and usually more intense. Owing to the inspiratory sound not continuing quite to the end of the inspiratory act, there is a very short interval

between the two sounds. In this latter point consists the only variation between the rhythm of the acts of breathing and that of the sounds.

The foregoing characters should not only be verified by the student, but he should become so familiar with them by practice that it requires no effort of the mind to recollect them. It will be seen hereafter that these characters of the normal laryngeal respiration are precisely those which distinguish an important morbid physical sign, namely, the bronchial or tubular respiration.

NORMAL VESICULAR MURMUR

This is the name usually given to the respiratory sounds heard over the different regions to the chest. These sounds should be studied with the ear applied directly to the chest (immediate auscultation), as well as with the stethoscope. In commencing the study, the middle of the anterior surface of the chest on the right side, to avoid the sounds of the heart, or, still better, the posterior aspect below the scapula on either side should be selected. The person examined should breathe somewhat more forcibly than in ordinary breathing, but not violently nor quickly, nor too slowly, the normal rhythm being unchanged. Children are better than adults for this study, owing to the greater intensity of the murmur in early life.

The characters which belong to the inspiratory and the expiratory sound in the normal vesicular murmur are as follows: The inspiratory sound is of

variable intensity. There is a wide variation in different healthy persons. In some persons it is so feeble as scarcely to be appreciable even with the binaural stethoscope. The pitch of the sounds, compared with the inspiratory sound in the normal laryngeal or tracheal respiration, is notably low. The quality of the sound is peculiar; no distinct idea of the quality can be formed by any comparison. The name used to designate the quality is *vesicular,* this name only denoting that the air-vesicles are in some way concerned in the production of the sound. This vesicular quality must be impressed upon the perception and memory by direct observation. The duration of the inspiratory sound is from the beginning to the end of the inspiratory act.

An expiratory sound is not always, although generally, appreciable. It is much less intense than the sound of inspiration. It is notably lower in pitch than the sound of inspiration. The quality of the sound is neither vesicular nor tubular. It may be called simply a blowing sound, and may be imitated by blowing with the mouth partially opened. The duration is much shorter than that of the inspiratory sound.

The characters, thus, which distinguish the normal vesicular murmur are, an inspiratory sound variable in intensity, low in pitch, and vesicular in quality; an expiratory sound less intense than the inspiratory, still lower in pitch, non-vesicular and non-tubular, or simply blowing; the inspiratory sound continuing from the beginning to the end of the

inspiratory act, and the expiratory sound beginning with the expiratory act but ending before this act is completed, its duration, relatively to the inspiratory sound, being variable, but averaging about a fifth. The inspiratory sound continuing to the end of inspiration, and the expiratory sound beginning with the act of expiration, it follows that there is no interval between the two sounds. It is to be remarked that an interval is not infrequently produced by the person examined holding the breath after inspiration is completed. This variation in the rhythm of the acts, of course, produces a corresponding variation in sounds of breathing.

The characters of the normal vesicular respiration may be studied by inflating the lungs removed from the human cadaver, or from the sheep or calf, and applying the binaural stethoscope directly upon the pulmonary surface. In this experiment the vesicular quality is strongly marked. In the same way the tracheal respiration may be studied and its characters contrasted with those of the vesicular respiration. It is recommended to the student to resort to this readily available method to study the normal respiratory signs.

Having become familiar with the characters of the normal vesicular respiration as compared with those of the normal laryngeal or tracheal respiration, the student may then proceed to study the former in the different regions of the chest. The murmur will be found to present variations in the different regions on the same side, and in the corresponding

regions on the two sides of the chest. The variations, within the range of health, in the latter are especially important. The following account of the murmur in the different regions embodies the results of the analysis of a series of recorded examinations of healthy persons.[1]

Right and Left Infra-clavicular Region.—The murmur in this region, on either side, differs more or less from the murmur as heard in the anterior regions below, or in the infra-scapular region. The vesicular quality in the inspiration is less marked. The pitch is higher. The expiratory sound is longer, less feeble, and higher in pitch. The difference between the two sides in this region is especially important with reference to diagnosis. The intensity of the inspiratory sound is almost invariably greater on the left side. Its vesicular quality is more marked, and the pitch is lower. *Per contra,* the inspiratory sound on the right side, in this region, is less intense, less vesicular, and higher in pitch than the inspiratory sound on the left side. In forced breathing the intensity of the murmur is increased more on the left than on the right side. The expiratory sound is sometimes wanting on the left, when it is heard on the right side. On the right side, the expiratory sound is longer than on the left side. It may be prolonged on the right side to nearly or quite the length of the inspiratory sound. Sometimes on the right side the pitch of the expiratory is higher than that of the inspiratory sound on the

[1] *Vide* Prize Essay, Trans. Amer. Med. Assoc., 1852, vol. v.

same side, and it may have a tubular quality. A rare peculiarity is a prolonged, high, tubular expiratory sound on both sides, analogous to the laryngeal or tracheal expiration. When this is the case, the pitch of the expiratory sound is higher on the left than on the right side

The most reasonable as well as the most recent explanation for the differences in the respiratory sounds in the right and left infra-clavicular regions, and an explanation which seems to be based on the best understanding of the problem, is one given by Fetterolf.[1] He ascribes the difference in intensity and character of the sounds on the right side to the fact that the trachea is throughout practically its entire thoracic course in contact with the right upper lobe, while it is separated from the left lung by 3 cm. or more of large bloodvessels, and esophagus with areolar and lymphatic tissue. It is this intimate relation with the trachea which seems to account for the greater length of the expiratory sound on the right side as well as for the other characteristic differences.

These several modifications of the respiratory murmur in the infra-clavicular region are marked in proportion as the sounds are studied near the sternum, that is, over the site of the primary bronchi. The respiratory murmur in this situation has been called the normal bronchial respiration, from its resemblance to the morbid sign so named. It may be more properly called a vesiculo-tubular, or the

[1] Arch. Int. Med., 1909, iii, No. 1.

normal broncho-vesicular respiration, the characters being those of the morbid sign which, under the latter name, will be described in the next chapter.

In the diagnosis of diseases, especially of phthisis, due allowance must be made for the points of disparity which exist normally between the two sides of the chest in the infra-clavicular region. Without a practical knowledge of these points of disparity error in diagnosis can hardly be avoided.

Right and Left Scapular Region.—As compared with the infra-clavicular region, the respiratory murmur heard over the scapula on either side is feeble, and the vesicular quality is less marked. The inspiratory sound is generally weaker and the pitch higher on the right than on the left side. The expiratory sound is more constantly heard on the right than on the left side. It may be prolonged on the right side, and is sometimes higher in pitch than the inspiratory sound. Compared with the left side, the murmur on the right, in this region, thus may have vesiculo-tubular or broncho-vesicular characters more or less marked.

Right and Left Inter-scapular Region.—In the upper and middle portions of this region, the normal characters are the same as in the sterno-clavicular portion of the infra-clavicular region. The same points of disparity between the two sides are more or less marked here as they are anteriorly over the site of the primary bronchi.

Right and Left Infra-scapular Region.—The intensity of the murmur is greater than over the scapular

region. In most persons there is no notable disparity between the two sides; when a disparity exists, the intensity is greater and the pitch lower on the left side. A prolonged, high-pitched, bronchial expiratory sound is sometimes transmitted below the scapula on the right side.

Right and Left Mammary and Infra-mammary Regions.—The inspiratory sound in these regions is less intense than in the infra-clavicular region; the vesicular quality is more marked, and the pitch is lower. An expiratory sound is often wanting.

Right and Left Axillary and Infra-axillary Regions.—The inspiratory sound in these regions is as intense as in any portion of the chest. The intensity is less in the infra-axillary than in the axillary region, and the pitch is lower. In some persons the murmur on the two sides presents no disparity, but in other persons the vesicular quality is somewhat more marked and the pitch is lower on the left than on the right side. An expiratory sound is oftener heard than in the mammary and infra-mammary regions.

NORMAL VOCAL RESONANCE

Laryngeal and Tracheal Voice.—It will prepare the student for the appreciation of the distinctive characters of the morbid signs pertaining to the voice to study the vocal signs over the larynx and trachea, Applying the stethoscope either over the broad surface of the thyroid cartilage, or just above the sternal notch, and requesting the person examined to count

with a moderate intensity of voice, the auscultator perceives a strong resonance, with a sensation of concussion or shock, and a sense of vibration, thrill, or fremitus. The voice seems to be concentrated and near the ear. Sometimes the articulated words are transmitted so as to be heard more or less distinctly. The laryngeal or tracheal voice (laryngophony, tracheophony) thus embraces different elements, namely, 1st, the vocal resonance; 2d, the concentration and nearness to the ear; 3d, the vibration, thrill, or fremitus; and 4th, the transmission of the speech, the latter corresponding to pectoriloquy. These different elements will be found to enter into the distinctive characters of morbid vocal signs.

The sounds heard over the larynx and trachea when words are spoken in a whisper should be studied, inasmuch as important morbid signs relate to the whispered voice. Whispered words occasion little or no shock or thrill, but an intense, high-pitched tubular sound, with a sensation as if a current of air were directed into the ear through the stethoscope. This sound corresponds to the sound of expiration in laryngeal or tracheal respiration; the two sounds are, in fact, identical if, as is the case with some exceptions, the person whisper with the expiratory breath. Articulated words are transmitted with more or less distinctness, thus corresponding with the morbid sign called whispering pectoriloquy.

Normal Thoracic Vocal Resonance and Fremitus.—The vocal resonance over the chest is to be studied both by means of the stethoscope and by immediate

auscultation. When the latter is employed the ear not applied to the chest should be closed in order to exclude the entrance of sound from the mouth of the person examined. When the stethoscope is employed, care must be taken, in making a comparison between the two sides of the chest, or between different regions on the same side, that the pectoral extremity of the instrument be pressed with an equal amount of force against the chest. The intensity with which the vocal resonance is transmitted is much affected by the degree of pressure with the stethoscope.

The situations in which the student should commence the study of the normal vocal resonance are those selected for beginning the study of the normal vesicular murmur, namely, the middle of the anterior aspect of the chest on the right side, and below the scapula behind.

With the stethoscope or the ear directly applied in the situations just named, the person examined should be requested to count one, two, three, in a uniform tone and with moderate force. The examiner should himself pronounce these numerals, in order to show the manner of counting. This is far better than asking a question and studying the resonance during the answer of the person examined. The objection to the latter mode is, the attention of the examiner is divided between the characters of the thoracic resonance and the idea conveyed by the answer. The characters of the vocal resonance in these situations are as follows.

The voice is heard with an intensity which varies

very much in different persons; in some the resonance is feeble, and it may be almost inappreciable, while in others it is quite intense. The intensity depends greatly on the loudness and lowness in pitch of the voice of the person examined. The resonance is notably weaker in women than in men. It is rarely attended with a sense of concussion or shock. It is diffused; that is, it does not seem to be concentrated like the tracheal or laryngeal vocal resonance. It evidently comes from a certain distance; that is, the sound does not seem to be near the ear. Impression of the distance of the sound is highly distinctive of the normal resonance as compared with a morbid vocal sign (bronchophony). The resonance is accompanied by a sense of vibration, thrill, or fremitus, the intensity of which, like the resonance, varies much in different persons. This fremitus is properly not an acoustic but a tactile sign. The normal vocal fremitus, together with its abnormal modifications, belong to the method of physical exploration called palpation. It is, however, appreciated by the ear as well as by the touch, and may be studied in the practice of auscultation. The student should practically distinguish from each other, and study separately, the vocal resonance and vocal fremitus.

From the foregoing characters the normal vocal resonance may be defined as diffused, distant, variable in intensity, and accompanied with more or less vibration, thrill, or fremitus.

Having become practically familiar with these characters of the normal vocal resonance in the situ-

ations in which they are first to be studied, the next object of study relates to the normal variations in the different regions on the same side of the chest, and in corresponding regions on the two sides. In giving an account of these variations, based on a series of recorded examinations in healthy persons, the different regions will be considered in the same order as in the study of the variations of the respiratory sounds (*vide* p. 96 *et seq.*).

Infra-clavicular Region. — The vocal resonance in this region on either side is more intense than in the anterior regions below, the intensity, however, in different persons being very variable. Irrespective of intensity, it is less diffused nearer the ear, and the pitch is somewhat higher. These latter variations are marked chiefly in the sterno-clavicular extremity of the region, that is, over the site of the primary bronchi. In some persons the concentration, nearness to the ear, and elevation of pitch, especially on the right side, are such as to approximate the normal resonance to the morbid sign called bronchophony. The characters of this sign will be considered in the next chapter, but it is important to know that exceptionally these characters may be, in a measure, illustrated in health in the infra-clavicular region. The resonance may then be termed normal bronchophony.

A comparison of the resonance in the region on the right side and on the left side always shows a disparity. The resonance on the right side is invariably greater. The degree of difference between the

two sides varies in different persons. The resonance may be more or less marked on the right and nearly wanting on the left side. Allowance is to be made for the points of normal disparity between the two sides in the diagnosis of disease; hence, the student must become practically familiar with them.[1]

The vocal vibration or fremitus varies fully as much as the vocal resonance in different persons. Its intensity is not always proportionate to that of the resonance; that is, the resonance may be comparatively weak when the fremitus is strong, and *vice versa.* The fremitus, like the resonance, is always greater on the right than on the left side, the disparity, like that of the resonance, varying considerably in different persons.

Scapular Region.—The resonance in this region is notably less intense than in the infra-clavicular region. It is also more diffused and distant. The intensity is always greater on the right side. These statements are alike applicable to the vocal fremitus.

Inter-scapular Region.—The intensity of the resonance here is nearly or quite as great as in the sterno-clavicular extremity of the infra-clavicular region. The resonance has in some persons in this region the characters of bronchophony. The intensity is always greater on the right side. The fremitus is more or less marked, and always more marked on the right than on the left side.

[1] For explanation, v. s., Fetterolf, Arch. Int. Med., 1909, iii, No. 1.

Infra-scapular Region.—As a rule, the resonance in this region is stronger than over the scapula. It is always characterized by diffusion and distance. As in all the regions, it varies much in different persons, and is stronger on the right than on the left side. These statements are also applicable to fremitus.

Mammary and Infra-mammary Regions.—The resonance is notably less than at the summit of the chest. The characters of bronchophony are never present. The intensity is greater on the right side. The same is true of fremitus.

Axillary and Infra-axillary Regions.—The resonance in these regions, and especially in the axillary region, is greater than over the mammary and infra-mammary regions. It is, of course, stronger on the right side. The characters as contrasted with those of bronchophony, namely, distance and diffusion, are marked. Fremitus is more or less marked, and, of course, more marked on the right than on the left side.

NORMAL BRONCHIAL WHISPER

Prior to the publication of the author's work on the *Physical Exploration of the Chest,* in 1856, signs in health and disease relating to the whispered voice had received but little attention. In that work, and more fully in the second edition, published in 1866, a series of signs accompanying whispered words were described and named. As a point of departure for the study of the morbid signs thus obtained, of

course the signs in health must first be studied. The sounds which are heard over different parts of the chest in health I have embraced under the name, the normal bronchial whisper. The pertinency of this name is derived from the fact that the conduction of the sound produced by the whispered voice must be chiefly by the air contained in the bronchial tubes. The sound heard over the trachea and larynx may be distinguished as the laryngeal or tracheal whisper, the characters of which have been already stated (*vide* p. 100).

It will facilitate the study of the normal bronchial whisper, as well as of the morbid signs, to consider that the characters of the sounds produced with the whispered voice are identical with those produced by the act of expiration, in all respects save intensity. Whispered words are produced, as a rule, by an act of expiration, the sounds being more intense generally than those which accompany even forced breathing. Curiously enough, there are exceptions to this rule. Some persons insist upon whispering with the act of inspiration, and there are some persons who have never acquired the ability to whisper. It will be at once evident that the pitch and quality of sounds, produced by whispered words with the act of expiration, must be the same as those of the sounds of expiration in breathing.

Selecting for the study of the normal bronchial whisper the same situations as in commencing the study of the normal respiratory murmur, and the normal vocal resonance—namely, the middle of the

chest in front, on the right side, and the infra-scapular region behind, with the whispered voice in these situations is heard, in most persons, a feeble, low-pitched blowing sound, these characters corresponding to those of the expiratory sound in forced breathing. The normal bronchial whisper in these situations is not in all persons appreciable.

In the infra-clavicular region, the bronchial whisper is heard, with variable intensity, in most persons. It is somewhat higher in pitch than the whisper below this region. It is louder and higher in the sterno-clavicular than in the acromial extremity. In the former situation it has not infrequently a tubular quality. It is louder on the right than on the left side of the chest. It is sometimes heard on the right when it is inappreciable on the left side. When heard on both sides the pitch of the sound is higher on the left than on the right side. It will be observed that these variations correspond to those of the sound with expiration in the infra-clavicular region (*vide* p. 96). Occasionally whispered words are partly transmitted, constituting incomplete whispering pectoriloquy.

In the scapular region the bronchial whisper is not infrequently wanting. It may be present on the right and not on the left side, and if present on both sides, it is always louder on the right side.

In the inter-scapular region, as a rule, it is nearly or quite as marked as over the site of the primary bronchi in front. The pitch is more or less high, and has a tubular quality. It is louder on the right

and higher in pitch on the left side, and in this situation there may be incomplete pectoriloquy.

In the infra-scapular region, it is not frequently wanting. When present it is generally feeble, the pitch being low and the quality non-tubular, or blowing. It is oftener wanting on the left than on the right side, and, if present on both sides, it is louder on the right side.

In the mammary and infra-mammary regions it is not infrequently wanting, and the statements just made with reference to the infra-scapular region are alike applicable to these, as, also, to the axillary and infra-axillary regions.

CHAPTER V

AUSCULTATION IN DISEASE

The respiratory signs of Disease — Abnormal modifications of the normal respiratory sounds—Increased vesicular murmur —Diminished vesicular murmur—Suppressed respiratory sound —Bronchial or tubular respiration—Broncho-vesicular respiration—Cavernous respiration—Broncho-cavernous respiration—Vesiculo-cavernous respiration—Amphoric respiration—Shortened inspiration—Prolonged expiration—Interrupted respiration—Adventitious respiratory sounds, or rales — Laryngeal and tracheal rales—Moist bronchial rales: coarse, fine, and subcrepitant—Vesicular or crepitant rale—Cavernous or gurgling rale—Pleural friction rales, metallic tinkling and splashing—Indeterminate rales—The vocal signs of disease—Bronchophony — Whispering bronchophony — Egophony — Increased vocal resonance — Increased bronchial whisper — Cavernous whisper — Pectoriloquy — Amphoric voice or echo — Diminished and suppressed vocal resonance—Diminished and suppressed vocal fremitus—Metallic tinkling—Signs obtained by acts of coughing or tussive sounds.

The importance of becoming perfectly familiar with the signs of health before entering upon the study of morbid signs, cannot be too strongly enforced. The auscultatory signs of disease, which are to be considered in this chapter, should not be studied until the student has made himself complete master of all the characters belonging to the normal signs obtained by auscultation.

Auscultation in disease embraces the signs produced by respiration, by the voice, and by acts of coughing. The respiratory signs will be first considered.

THE RESPIRATORY SIGNS OF DISEASE

The morbid signs produced by respiration may be classified as follows: 1st. Those which are abnormal modifications of the normal respiratory sounds. 2d. Those which have no analogues in health, being entirely new or adventitious sounds. The latter are usually embraced under the name rales.

ABNORMAL MODIFICATIONS OF THE NORMAL RESPIRATORY SOUNDS

In order to appreciate the distinctive characters of the signs embraced in this class, the characters which distinguish the normal vesicular murmur must be kept in mind. The abnormal modifications which characterize these morbid signs relate to intensity, pitch, and quality of sound, together with certain alterations in rhythm. Twelve signs are included under this heading, namely: 1. Increased vesicular murmur. 2. Diminished vesicular murmur. 3. Suppression of respiratory sound. 4. Bronchial or tubular respiration. 5. Broncho-vesicular respiration. 6. Cavernous respiration. 7. Broncho-cavernous respiration. 8. Vesiculo-cavernous respiration. 9. Amphoric respiration. 10. Shortened inspiration. 11. Prolonged expiration. 12. Interrupted respiration.

These signs are to be studied, first, with reference to their distinctive characters severally, each being contrasted, as respects these characters, with the other morbid respiratory signs as well as with the normal vesicular murmur; and, second, with reference to the morbid physical conditions which they severally represent, that is, the diagnostic significance which belongs to each.

Increased Vesicular Murmur.—This sign has but a single distinctive character, namely, increase of intensity. The murmur is abnormally loud, the characters of the normal vesicular murmur being in other respects not materially changed, that is, the pitch is low and the quality vesicular as in health. Now, it has been seen (*vide* p. 94) that the intensity of the healthy murmur varies much in different persons; there is no ideal standard of normal intensity by reference to which an abnormal increase is to be determined. Yet the increase under certain conditions of disease is such that the fact is sufficiently evident. It occurs on the healthy side of the chest when the respiratory function on the other side is annulled or much compromised by disease. This takes place in cases of pleurisy with large effusion, pneumonia, especially if more than one lobe be affected, obstruction of one of the primary bronchi, and in pneumothorax. The sign does not possess great diagnostic importance inasmuch as the nature and extent of the disease are ascertained by the signs obtained on the affected side.

The sign has been called *supplementary* and *puerile* respiration.

If the murmur be much intensified, it may possibly be mistaken for other morbid signs, namely, bronchial or broncho-vesicular respiration. This error, however, can never be made if the distinctive characters of these signs relating to pitch and quality have been correctly studied.

Diminished Vesicular Murmur.—The intensity of the vesicular murmur may be, on the one hand, diminished when it is evident that in other respects there is no material change, and the murmur, on the other hand, may become so feeble that characters aside from the intensity are not determinable. From the latter fact it follows that the murmur must sometimes be considered as only weakened, when, were the diminished intensity not as great, morbid changes in pitch and quality might be appreciable.

The murmur is more or less weakened in cases of dilatation of the air-cells, or vesicular emphysema, the sign, in these cases, being often accompanied by changes in rhythm, namely, a shortened inspiration and a prolonged expiration. Simple weakness of the murmur may also be incident to partial blocking of the air-vesicles with blood or serum in cases of pulmonary extravasation and edema. A deficient expansion of the chest, either on one side or on both sides, occasions weakness of the respiratory murmur. Deficient expansion of one side, or of both sides, may be caused by paralysis, bilateral or unilateral, of the costal muscles. A similar effect is caused

by paralysis of the diaphragm. The incomplete descent of the diaphragm from pain, as in peritonitis, or from mechanical obstacles, as in peritoneal dropsy, pregnancy, and abdominal tumors, weakens the respiratory murmur, the increased action of the costal muscles not being fully compensatory. Unilateral deficiency of expansion of the chest is caused by pain in intercostal neuralgia, pleurodynia, acute pleurisy, and pneumonia; it is also caused by the presence of a stratum of liquid, air, or a thick layer of lymph, between the lung and the chest-wall in pleurisy, hydrothorax, and pneumothorax. Swelling of the bronchial mucous membrane in bronchitis affecting the larger tubes, must diminish somewhat the intensity of the murmur. In primary bronchitis the murmur is diminished on both sides. In bronchitis affecting the smaller tubes the murmur is greatly diminished, if not suppressed, on both sides. Incomplete obstruction of bronchial tubes from the presence of mucus, serum, blood, or pus, has this effect over an area corresponding to the size of the tubes obstructed. Spasm of the bronchial muscular fibres in paroxysms of asthma, diminishes, if it does not suppress, murmur on both sides. Another cause of diminution, unilateral or within a limited space on one side, is the presence of a tumor pressing on bronchial tubes, as in cases of aneurysm. A permanent contraction or stricture of bronchial tubes is another cause. Not infrequently the pressure of an aneurismal tumor or an enlarged bronchial gland on a primary bronchus, occasions notable weakness of the murmur over the whole of one side; and the

pressure of a tumor on the trachea weakens the murmur, more or less, on both sides. A foreign body in one of the primary bronchi weakens it on one side. Diminution of the calibre of the trachea or larynx from morbid growths, the presence of foreign bodies, fibrinous exudations, accumulations of mucus, submucous infiltration, spasms of the laryngeal muscles, and swelling of the mucous membrane, weakens, in proportion to the amount of obstruction, the murmur on both sides without any material change in its quality and pitch.

Weakened murmur at the summit of the chest, without other appreciable abnormal characters, occurs in some cases of phthisis, due to obstructed bronchial tubes from coexisting circumscribed bronchitis, or to deficient superior costal movements of the chest, as well as to the presence of exudation in the air-vesicles.

Diminished intensity of the vesicular murmur is thus seen to be a respiratory sign entering into the diagnosis of a considerable number of diseases, namely, emphysema, paralysis affecting the respiratory muscles, asthma, abdominal affections interfering with the diaphragmatic movements, intercostal neuralgia, pneumonia, fibrinous pleurisy, hydrothorax, bronchitis, aneurismal and other tumors, permanent constriction or stricture of bronchial tubes, laryngitis, edema of the glottis, spasm of the glottis, the various lesions which occasion obstruction of the larynx or trachea, and phthisis.

In determining a slight abnormal weakness of the respiratory murmur at the summit of the chest on

the right side, the normal disparity between the two sides in this situation is to be borne in mind. The vesicular murmur is normally less intense on the right than on the left side.

This sign occurring in so many diseases, it is obvious that, taken alone, that is, independent of other signs, it has not any special diagnostic significance. It is, however, often of value in diagnosis, when taken in connection with other signs. It is chiefly useful when it exists either over the whole or in a part of the chest on one side.

Suppressed Respiratory Sound.—This sign is easily defined, namely, absence of all respiratory sound, as the name signifies. It cannot, of course, have any characters relating to intensity, pitch, and quality.

Suppression of respiratory sound represents the same physical conditions as diminished vesicular murmur; the physical conditions represented by the latter sign, existing in a greater degree, occasion absence of all sound. It suffices, therefore, to recapitulate the various conditions and diseases in connection with which the murmur may either be diminished or suppressed. Suppression over portions of the chest may be due to dilatation of the air-cells in cases of emphysema. It occurs from the exclusion of air from the vesicles by the presence of blood and serum in cases of pulmonary extravasation and edema. Respiratory sound is sometimes wanting over lung solidified in cases of pneumonia and phthisis. Paralysis of the muscles concerned in respiration may possibly involve feebleness of the

respiratory acts sufficiently to render the murmur inappreciable. In intercostal neuralgia, pleurodynia, acute pleurisy, and pneumonia, the movements of the affected side may be so much restricted as to abolish the murmur. In pleurisy with much effusion, empyema, hydrothorax, pneumothorax, the murmur is suppressed over either a part or the whole of the affected side, the extent of the suppression corresponding to the quantity of serum, pus, or air within the pleural cavity. Swelling of the mucous membrane in cases of bronchitis affecting the larger bronchial tubes is never sufficient to suppress the murmur, but plugging of more or less of the tubes with mucus or other morbid products may have this effect. In cases of bronchitis, the murmur is sometimes found to have disappeared over a certain area, and to return after an act of expectoration. In bronchitis affecting the smaller tubes, suppression of the murmur is not infrequent. It occurs from spasm of the bronchial muscular fibres in cases of asthma. The pressure of a tumor, morbid growths, or deposits from bronchi, within the lungs, may abolish respiratory sound over a portion of the chest, and permanent stricture or obliteration of bronchial tubes must have this effect. Respiratory sound may be suppressed over the whole of one side from the pressure of an aneurysmal or some other tumor upon one of the primary bronchi. If the tumor press upon the trachea, the obstruction may be sufficient to suppress the murmur on both sides. A foreign body lodged in a primary bronchus may suppress the murmur on one side, and, lodged in the larynx or

trachea, the murmur may be suppressed on both sides. The different affections of the larynx and trachea which, in proportion to the amount of obstruction, weaken the murmur, may render it inappreciable.

Bronchial or Tubular Respiration.—The analogue of this sign is the normal laryngeal or tracheal respiration (*vide* p. 92). The characters which distinguish the latter normal sign from the normal vesicular murmur, are those which are distinctive of the bronchial or tubular respiration. These characters, relating to the inspiratory and the expiratory sounds, are as follows: The inspiratory sound is of variable intensity. Intensity does not enter into the distinctive characters of this sign; the sound may be either louder or weaker than the inspiratory sound in health. The pitch of the inspiratory sound is high. The quality is expressed by the term tubular; it is like the sound produced by blowing through a tube, this quality taking the place of that expressed by the term vesicular in the normal respiration. The expiratory sound is prolonged; it is as long as, or longer than, the sound of inspiration, and is usually louder. The pitch is still higher than that of the inspiratory sound. The quality, like that of the inspiratory sound, is tubular, this quality taking the place of the simple blowing quality of the expiratory sound in the normal vesicular murmur. With the normal rhythm of the respiratory acts there is a very brief interval between the sounds of inspiration and expiration, due to the fact that the inspiratory sound ends a little before the end of the inspiratory act.

The morbid physical condition represented by this important sign is either complete or considerable solidification of lung. Whenever the chest is auscultated over lung solidified, if there be not absence of respiratory sound, the sound is tubular. This significance renders the sign of diagnostic value in the diseases which involve solidification. The sign *per se* denotes simply this morbid physical condition; the particular disease which exists is ascertained by means of the associated signs and the symptoms.

Solidification of lung is incident to several different diseases. In lobar pneumonia it is due to a fibrinous exudation within the air-vesicles. In phthisis it is caused by an exudation in the same situation. In chronic or fibroid pneumonia the lung is solidified by an interstitial growth. The compression of lung from either pleuritic effusion, an accumulation of air in the pleural cavity, or the pressure of a tumor, causes solidification by condensation. Collapse of pulmonary lobules also solidifies by condensation. Coagulation of blood within the air-vesicles (hemorrhagic infarctus), and neoplastic infiltration or growth, are other causes of solidification. In these different affections, if the solidification be complete or considerable, this sign is usually present; it is always present if there be not suppression of respiratory sound.

It is sometimes the case that either the inspiratory or the expiratory sound is wanting. The characters of the sign suffice for its recognition if either the inspiratory or the expiratory sound be alone present; the pitch and the quality are distinctive. Both sounds

are often so intense that they are diffused more or less without the limits of the solidified portion of lung. The expiratory sound, being more intense than the inspiratory, is transmitted farther than the latter. This explains the conjunction sometimes of a vesicular inspiration with a tubular expiration; and a cavernous inspiration may be conjoined with a tubular expiration, showing the proximity of solidified lung in the former case to healthy lung, and in the latter case to a pulmonary cavity.

The sound may seem near the ear, or to come from a certain distance. The latter is appreciable in some cases of large pleuritic effusion; the tubular respiration is more or less distant, and it is sometimes diffused over the whole of the side which is filled with liquid.

Broncho-vesicular Respiration.—This name was introduced by me, in 1856, to denote the combination, in varying proportions, of the characters of the bronchial or tubular, and of the normal vesicular respiration. The name expresses such a combination. It embraces modifications to which have been applied the terms, *rude, rough,* and *harsh respiration,* and those included by German authors under the name *indeterminate* respiratory sounds.

The sign represents the different degrees of solidification of lung, between an amount so slight as to occasion only the smallest appreciable modification of the respiratory sound, and an amount so great as to approximate closely to the degree giving rise to bronchial or tubular respiration. In other words,

all the gradations of respiratory modifications, caused by incomplete or an inconsiderable solidification, which fall short of bronchial or tubular respiration, are embraced under the name broncho-vesicular. The gradations correspond to the amount of solidification, that is, they show the solidification to be either very slight, slight, moderate, or nearly sufficient to be considered as considerable or complete. The sign is, therefore, important as evidence, first, of the existence of solidification; and, second, of the degree of solidification.

Analyzing this sign, the most distinctive feature is the combination of the vesicular and the tubular quality in the respiratory sound. These two qualities may be combined in variable proportions. The pitch of the sound is raised in proportion as the tubular predominates over the vesicular quality. The expiratory sound is more or less prolonged, tubular in quality, and the pitch is raised. The prolongation of this sound, its tubular quality, and the highness of pitch, are proportionate to the predominance of the tubular over the vesicular quality in the inspiratory sound. If the solidification of lung be slight, the characters of the normal vesicular respiration predominate; that is, the inspiratory sound has but a small proportion of the tubular quality, and is but little raised in pitch, the expiratory sound being not much prolonged, its tubularity not marked, the pitch not high. If, on the other hand, the solidification of lung be almost enough to give a bronchial respiration, the inspiratory sound has only a little vesicular quality, the tubular

quality predominating, the pitch proportionately raised; and the expiratory sound is prolonged, tubular, and high, nearly to the same extent as in the bronchial respiration. The less the solidification, the more the characters of the normal vesicular predominate over those of the bronchial respiration, and, *per contra,* the greater the solidification the more the characters of the bronchial predominate, over those of the normal vesicular respiration. Daily auscultation in a case of lobar pneumonia during the stage of resolution affords an opportunity to study all the gradations of this sign. After resolution has made some progress the inspiratory sound is no longer purely tubular, but the ear appreciates a little admixture of the vesicular quality and the pitch is slightly lowered. As resolution goes on the vesicular quality increases, the pitch is correspondingly lowered, until, at length, no tubularity remains, and the pitch becomes normal. Meanwhile, as the vesicular quality increases in the inspiratory sound, the expiratory sound is less and less prolonged, high and tubular, until it becomes, as in health, short, low, and blowing.

The broncho-vesicular respiration is an important diagnostic sign in all the affections which involve partial solidification of lung. In lobar pneumonia, as just stated, it denotes the progress made from day to day in resolution. It is found also in an earlier stage, before the solidification is sufficient to give rise to a purely bronchial respiration. It is a valuable sign in phthisis, affording evidence, not only of the fact of solidification, but of its degree and extent.

The sign enters into the diagnosis of interstitial pneumonia, hemorrhagic infarctus, condensation of lung from the pressure of either liquid, air, or a tumor, and from collapse of pulmonary lobules. It may be stated with respect to this sign, that it is always present if the lung be partially solidified, provided there be not either suppression of respiratory sound, or such a degree of feebleness that the distinctive characters are undeterminable. As with the bronchial respiration, so with the broncho-vesicular, either the inspiratory or the expiratory sound may be wanting. The characters of the sign are then to be determined as they are manifested in the sound which is present, namely, the combination of the vesicular and the tubular quality, with more or less elevation of pitch, if only an inspiratory sound may be heard, and the amount of prolongation, tubularity, and elevation of pitch, if there be only an expiratory sound.

In determining the presence of this morbid sign at the summit of the chest on the right side, it is to be borne in mind that the respiratory murmur on this side has, in health, as compared with the respiratory murmur at the summit on the left side, more or less of the characters of the broncho-vesicular respiration (*vide* Normal Broncho-vesicular Respiration, p. 119).

Cavernous Respiration.—The modifications which constitute the distinctive characters of this sign are produced by the entrance of air into a cavity with the act of inspiration, and its exit from the cavity with the act of expiration. This passage of air into

and from a cavity can only take place where the walls of the cavity collapse more or less in expiration and expand in inspiration. Pulmonary cavities occur chiefly in cases of phthisis. They occur, but with comparative infrequency, as a result of circumscribed abscess and gangrene of lung.

A well-marked cavernous respiration has characters which are highly distinctive when this sign is contrasted, on the one hand, with either the bronchial or broncho-vesicular respiration, and, on the other hand, with the normal vesicular murmur. These distinctive characters relate both to the inspiratory and expiratory sound. The inspiratory sound is neither vesicular nor tubular in quality, and the pitch is low as compared with the bronchial respiration. As regards quality, we may say of it, as of the expiratory sound in the normal vesicular respiration, it is simply a blowing sound. The expiratory sound has the same quality as the inspiratory, and it is lower in pitch. Its duration is variable. The intensity of both the inspiratory and the expiratory sound varies; intensity does not enter into the distinctive characters of this sign more than into those of the bronchial and the broncho-vesicular respiration. With a practical knowledge of the foregoing characters distinctive of the cavernous respiration, there is no difficulty in discriminating this sign from the bronchial respiration. The sign is more likely to be confounded with the normal vesicular murmur, inasmuch as it differs from the latter only in the absence in the inspiratory sound of the vesicular

quality. Against this error the student is to be cautioned. It is most likely to be made when the inspiratory sound is much weakened, and, consequently, the vesicular quality less distinctly appreciable than when the sound is more or less intense.

A cavernous respiration is limited to a space more or less circumscribed, the area corresponding to the site and the size of the cavity. Occurring, for the most part, in cases of phthisis, it is much oftener found at the summit than elsewhere over the chest. It is not constantly found where there is a cavity with flaccid walls. It may be temporarily suppressed by the presence of liquid within the cavity, and by obstruction of the orifices communicating with bronchial tubes, or of the latter. It may be wanting at one moment, and an act of expectoration may cause it to reappear. Hence absence of cavity cannot be predicated on the absence of the sign at a single examination. Moreover, if a cavity be not situated near the pulmonary superficies, and solidified lung intervene between it and the walls of the chest, the cavernous sign may be drowned in a loud bronchial respiration. For this reason, while the cavernous sign is positive evidence of a cavity, the absence of the sign is not proof that a cavity does not exist.

In some cases of perforation of lung with pneumothorax, the passage of air to and fro through the perforation may give rise to the cavernous respiration. As a rule, however, under these circumstances, another sign is produced, namely, the amphoric respiration.

The cavernous respiration may be reproduced by

the inflation of lungs after their removal from the body, the binaural stethoscope being placed over a cavity. This is true, also, of the bronchial and the broncho-vesicular respiration. These signs may be thus illustrated not infrequently after death from phthisis, in lungs in which are cavities together with portions completely or moderately solidified.

The distinctive characters of the cavernous respiration may also be illustrated by means of a small India-rubber balloon with openings at opposite ends. Inflating the balloon through a tube introduced into one opening produces a sound analogous to the cavernous inspiration, and the expulsion of the air by the elasticity of the balloon produces a sound analogous to the cavernous expiration. A Davidson's syringe may be used to inflate the balloon. The sounds are heard by applying lightly to the balloon the binaural stethoscope. This illustration demonstrates the mechanism of the cavernous respiration.

Broncho-cavernous Respiration.—In this sign, as the name denotes, the characters of the bronchial and the cavernous respiration are combined. These characters may be combined in different ways, as well as in variable proportions. If a cavity be situated in proximity to solidified lung, the quality and pitch of the inspiratory and the expiratory sound may show an admixture of the characters of the two signs, and to a practised ear the combination is distinctly recognizable. This is one of the forms of broncho-cavernous respiration; the sounds are not sufficiently high and tubular for bronchial, nor suffi-

ciently low and blowing for cavernous respiration. Another form consists of an inspiratory sound, the first part of which is tubular, and the latter part cavernous. Examples of this form are not extremely infrequent (metamorphosing respiration). Still another form is a cavernous inspiratory, with a bronchial or tubular expiratory sound. In the latter form, the bronchial expiration proceeds from solidified lung situated near the cavity, the intensity of the sound being sufficient to drown the cavernous expiration.

When, as often happens, a cavity is situated in close proximity to, or, it may be, surrounded by solidified lung, the cavernous and the bronchial respiration are, as it were, in juxtaposition, and such instances offer an excellent opportunity to study the points distinguishing these signs from each other; and, generally, at a short distance the normal vesicular murmur may be found, so that both morbid signs may be compared with the latter. Within a circumscribed area sometimes are exemplified the characters of the normal murmur, and of the two morbid signs just mentioned, together with those of the broncho-vesicular respiration.

Vesiculo-cavernous Respiration.—It is sometimes evident that the vesicular and the cavernous quality are combined in the inspiratory sound. This occurs when a cavity is surrounded, not by solidified, but by healthy lung. Under these circumstances, over the site of the cavity the inspiratory sound may be as loud as, or louder than, that around the cavity, but the quality is not purely cavernous; some vesic-

ular quality is appreciable. A vesiculo-cavernous respiration, then, is a cavernous respiration *plus* some vesicular quality derived from the air-vesicles which are proximate to the cavity. This sign is corroborated by other associated signs showing the existence of a cavity and its localization.

Amphoric Respiration.—The term amphoric has a significance when applied to auscultatory sounds, analogous to that which it has in percussion; it denotes a musical intonation which may be compared to the sound produced by blowing upon the open mouth of a decanter or phial. Whenever the respiratory sound has this intonation, it denotes a space containing air which is not expelled with the act of expiration. Air in the pleural cavity, with perforation of lung, is the physical condition most frequently represented by this sign. It is a valuable diagnostic sign in cases of pneumothorax; but it is not always present in that affection, certain accessory conditions being requisite—namely, perforation above the level of liquid, and an unobstructed communication of the bronchial tubes, through the opening, with the pleural space containing air. While, therefore, its presence is significant of pneumothorax, its absence is by no means sufficient to exclude this affection. Not infrequently it is a sign of a phthisical cavity with rigid walls which do not collapse with the act of respiration. The same contingencies affect its production here as in cases of pneumothorax. Whenever amphoric respiration is present, if pneumothorax be excluded by the absence of the other signs which are diagnostic of this affection,

the sign is proof of the existence of a pulmonary cavity, the walls of which are not flaccid. The sign then takes the place of the ordinary cavernous respiration which has been described.

The amphoric sound may accompany either inspiration or expiration, or both. Amphoric respiration may be artificially illustrated by connecting an India-rubber bag of considerable size (such as is contained within a foot-ball) with a flexible tube, and after dilating it with air, inflating it forcibly either by a pair of bellows or by the mouth, holding the bag close to the ear. The amphoric sound thus produced represents the amphoric respiration as a sign in pneumothorax. As the sign of a tuberculous cavity it may be illustrated by a similar experiment, using an India-rubber bag of the size of an egg or orange. I have localized a tuberculous cavity with rigid walls in the centre of a lobe, by inflating artificially phthisical lungs after their removal from the body.

Shortened Inspiration.—The inspiratory sound is somewhat shortened in bronchial or tubular respiration. This modification enters into the characters of that sign, the quality of the sound being tubular, and the pitch high. The shortening is due to the sound ending before the inspiratory act ends; the sound is said to be unfinished. Shortening of the sound occurs, however, when it is not an element in the bronchial respiration. The shortening is then due to the sound not beginning with the inspiratory act; this is distinguished as deferred inspiratory sound. A deferred inspiratory sound not tubular

in quality, but more or less vesicular, and not notably raised in pitch, is a sign of pulmonary or vesicular emphysema. It is a sign of value in connection with the diagnosis of that disease.

The student should note the distinctions just stated, which relate to pitch and quality. Suppose an inspiratory sound to be present without an expiratory sound; if the sound be shortened at the end of the inspiration, the pitch high, and the quality tubular, it is bronchial respiration, denoting complete or considerable solidification of lung; but if the shortening be at the beginning of inspiration, the pitch comparatively low, and vesicular quality be appreciable, the sign denotes emphysema. The differential points thus are, the inspiratory sound either unfinished or deferred, the pitch either high or low, and the quality either tubular or vesicular. Attention to these points is essential in order to avoid error in the interpretation of the sign.

Prolonged Expiration.—The length of the expiratory sound in health varies in different persons. The sound is sometimes considerably prolonged; it may be nearly as long as the sound of inspiration. There is no difficulty in recognizing this as a normal peculiarity, from the fact that the murmur has the pitch and quality of health. An unusual length of the expiratory sound, within the range of health, is usually observed at the summit of the chest, and especially on the right side. It is important to bear in mind that at the summit of the chest on the right side, and sometimes also on the left side, a prolonged expiratory

sound, more or less raised in pitch, and tubular in quality, may be a normal peculiarity. It follows that a prolonged, and even a high and tubular expiration at the summit of the chest, must not be reckoned as a morbid sign unless it be associated with other signs denoting disease. The laws of the disparity between the two sides of the chest at the summit are to be taken into account (*vide* p. 96). If the expiration be longer on the left than on the right side, it is abnormal; so, also, is a high-pitched tubular expiration heard on the left and not on the right side.

The significance of an abnormally prolonged expiration depends on its pitch and quality. If it be high and tubular, it denotes solidification of lung. It is, in fact, bronchial respiration. As already stated, in bronchial or tubular respiration the inspiratory sound is sometimes wanting, and the presence of the sign is then to be determined by the characters, relating to pitch and quality, of the expiratory sound. The same statement holds true with respect to broncho-vesicular respiration when this approximates to the bronchial. At the summit of the chest, the characters of the inspiratory sound, and associated morbid signs, always enable the auscultator to determine whether a prolonged high and tubular expiration be, or be not, abnormal. A prolonged expiration, which is low in pitch and blowing in quality, that is, with the characters of health, aside from length, may belong to a cavernous expiration. This is to be determined by the characters of the inspiration, and by other associated signs. Exclusive of cavernous respiration, an

abnormally prolonged expiratory sound of low pitch and non-tubular, denotes vesicular emphysema. It is associated then with a weakened and deferred inspiratory sound. A prolonged expiratory sound, in cases of emphysema, is invariably low and non-tubular. If it have not these characters, it is not a sign of emphysema, but belongs to bronchial or broncho-vesicular respiration. Attention to these differential points is to be enjoined upon the student.

A prolonged expiration at the summit of the chest on the right side is sometimes incorrectly considered to be evidence of phthisis. It is to be recollected, in the first place, that prolongation of this sound with a normal pitch and quality, is never evidence of solidification of lung either from phthisis or any other disease; and in the second place, even if the pitch be high, and the quality tubular, that it is not to be regarded as abnormal provided the inspiratory sound is unchanged, and other signs of disease are not present. At times in bronchitis, there is a prolonged expiratory sound which may be distinguished as a sonorous expiration, not amounting to a rale. This is likely to be mistaken for broncho-vesicular breathing.

Interrupted Respiration.—To this sign have been applied other names, such as *jerking, wavy, cogged wheel,* and by French writers the names *entrecoupée* and *saccadée.* The modification is either of the inspiration or of the expiration, or of both. The inspiratory, however, much more frequently than the expiratory, sound is interrupted. The sound, instead,

of being continuous, is broken into one, two, or more parts. This is the characteristic of the sign. If at the same time there be alterations in pitch and quality, the interruption is merely incidental to other signs—namely, the bronchial, broncho-vesicular, or cavernous respiration. To constitute it a distinct sign, the interruption must be the only appreciable change. As a distinct sign it has but little diagnostic value.

Interrupted respiration is sometimes found in healthy persons. It is confined to the summit of the chest, and oftener on the left than the right side. Existing without any other signs, therefore, it is not evidence of disease. It is of value only in the diagnosis of phthisis. Associated with other signs, when the latter are not marked, it is entitled to a certain amount of weight in the diagnosis.

Interrupted respiratory sounds, of course, occur when there is interruption in the respiratory movements. This happens in cases of pleurisy, pleurodynia, or intercostal neuralgia. Owing to the pain caused by the movements in respiration, the patient may breathe, not continuously, but with a series of jerking movements. Sometimes interrupted breathing is observed in persons who are excited or agitated when auscultation is practised. In all these instances interruption in the respiratory sounds is found over the whole chest, whereas, when it is an abnormal sign in cases of phthisis, it is limited to the summit on one side of the chest, and there is no interruption manifested in the mode of breathing.

Summary.—Reviewing the foregoing signs, they may be distributed into three classes, as follows: (1) Signs, the distinctive characters of which relate either to the absence or to the intensity of sound. This class embraces (*a*) increased intensity of the vesicular murmur; (*b*) diminished intensity of the vesicular murmur; and (*c*) suppression of respiratory sound. (2) Signs, the distinctive characters of which relate especially to pitch and quality. In this class belong (*a*) bronchial or tubular respiration; (*b*) broncho-vesicular respiration; (*c*) cavernous respiration; (*d*) broncho-cavernous respiration; (*e*) vesiculo-cavernous respiration; and (*f*) amphoric respiration. (3) Signs, the distinctive characters of which relate especially to rhythm—namely, (*a*) shortened inspiration; (*b*) prolonged expiration; and (*c*) interrupted respiration.

ADVENTITIOUS RESPIRATORY SOUNDS, OR RALES

Adventitious respiratory sounds, or, adopting the French term, rales, are distinguished from the morbid signs already considered, by the fact that they have no analogues in health; in other words, they are not normal sounds abnormally modified, but wholly new sounds. A convenient classification of these signs is based on the different anatomical situations in which they are produced. This classification is as follows: (1) Laryngeal and tracheal rales; (2) bronchial rales; (3) vesicular rales; (4) cavernous rales; (5) pleural rales; and (6) indeterminate rales. Compared with each other, as regards their characters,

they admit of being divided into dry and moist rales, the latter being evidently due to the presence of liquid.

Laryngeal and Tracheal Rales.—The rales produced within the larynx and trachea may be either moist or dry. The moist or bubbling sounds are produced when mucus or other liquid accumulates in these sections of the air-tubes. This occurs frequently in the moribund state, and the sounds are then known as the "death-rattles." When not incident to this state, they denote either insensibility to the presence of liquid, as in coma, or inability to effect the removal of the liquid by acts of expectoration. The sounds are heard at a distance. They exemplify, on a large scale, moist or bubbling auscultatory sounds which are produced within the bronchial tubes. Dry sounds produced within the larynx or trachea are caused by spasm of the glottis, and by diminution of the calibre, either at or below the glottis, from edema, exudation, the presence of a foreign body, or the pressure of a tumor. The dry sounds are distinguished as whistling, wheezing, crowing, whooping, etc. They are heard at a distance, and they also exemplify auscultatory sounds representing analogous conditions in the bronchial tubes. Characteristic sounds, produced at the glottis by spasm, enter into the diagnosis of certain affections — namely, laryngismus stridulus, pertussis, croup, and aneurism involving excitation of the recurrent laryngeal nerve. Other sounds are due to paralysis of the laryngeal muscles. Again, dry sounds produced by stenosis of the trachea from the

pressure of an aneurismal or other tumor, cicatrization of ulcers, and morbid growths, are of diagnostic importance. Although audible without auscultation, these different sounds, with reference to the precise situation at which they are produced, may sometimes be studied with advantage by means of the stethoscope. They are embraced under the name stridor. The respiration, voice, and cough, when accompanied by these sounds, are said to be stridulous.

MOIST BRONCHIAL RALES

The moist bronchial rales are bubbling sounds produced in different branches of the bronchial tree. They are sounds of which the "tracheal rattles" are an exaggerated type. They may be imitated by blowing into liquids through tubes differing in size. They may also be produced in the lungs of the sheep or the calf, after removal from the body, by injecting into the bronchi glycerin or some other liquid, and imitating the respiratory acts by means of a pair of bellows, auscultation being practised with the stethoscope applied upon the surface of the lung, or with several thicknesses of cloth intervening. The bubbles seem to be large or small according to the size of the bronchial tubes in which they are produced. Apparent differences in the size of the bubbles are distinguished by the names coarse and fine. In the primary and secondary bronchial branches the moist sounds are relatively quite coarse; they are less so in tubes of the third or fourth dimensions; in smaller tubes they

become fine, and in those of minute size they become extremely fine.

Extremely fine bubbling sounds constitute what has been known as the subcrepitant rale, so-called because it approaches in character to the crepitant rale, produced within the air-vesicles and bronchioles. We may thus judge of the size of the bronchial tubes in which the rales are produced by their comparative coarseness or fineness. Frequently, however, coarse and fine rales are intermingled, and generally, those which are either coarse or fine are not uniform, but appear to be of unequal size. In all the varieties of the moist bronchial rales, the bubbling character of the sounds is sufficiently distinctive for their recognition. The differentiation of the so-called subcrepitant from the crepitant rale alone involves some nice points of distinction.

Coarse bubbling rales sometimes occur in acute bronchitis affecting the larger bronchial tubes. Their occurrence is exceptional, because, in general, the mucus within the tubes does not accumulate sufficiently and is too consistent for the production of bubbling sounds. These rales occur in cases in which the mucus is unusually thin, and either more abundant than usual, or an accumulation takes place in consequence of inability to expectorate freely. These conditions are wanting in the majority of the cases of ordinary acute bronchitis. A muco-purulent liquid in cases of chronic bronchitis is better suited for the production of bubbling sounds than simple mucus. Moreover, coarse rales are heard oftener in children

than in adults, because the former do not voluntarily expectorate as freely as the latter. Serous transudation (bronchorrhea) into tubes of large size may give rise to coarse bubbling rales, and also the presence of blood in some cases of profuse hemorrhage. In bronchitis and bronchorrhea the rales are heard on both sides of the chest. The bubbling rales, whether coarse or fine, are heard either with the act of inspiration or of expiration, or with both acts.

Fine bubbling sounds and the so-called subcrepitant rale occur in various pathological connections. The characters of the latter are to be borne in mind with reference to the discrimination from the crepitant rale. The most distinctive character is the moist sound or bubbling; this is sufficiently appreciable. Other characters are, their occurrence frequently, but not constantly, in expiration as well as in inspiration, and the inequality of the fine bubbling sounds.

The so-called subcrepitant rale, existing over the chest on both sides, is diagnostic of bronchitis affecting the smaller bronchial tubes (capillary bronchitis), when taken in connection with other signs, and the symptoms. The rales exist on both sides, because this, as well as bronchitis affecting the larger tubes, is a bilateral affection. The sign is of great practical value in the diagnosis of that variety of bronchitis. The rale also occurs on both sides, and is more or less diffused in pulmonary edema. The connection with the latter affection is shown by the associated physical signs, together with the symp-

toms. In so-called capillary bronchitis, the bubbling is due to the presence of thin mucus, and in pulmonary edema to serous transudation within the small bronchial ramifications.

Fine bubbling or the so-called subcrepitant rale has other pathological connections, as follows:

1. It occurs in lobar pneumonia during the stage of resolution. Here it is due to the presence of mucus from a bronchitis limited to the affected lobe or lobes, and, in a measure, to liquefied pneumonic exudation. It is considered as denoting commencing, and progressing resolution in pneumonia. Sometimes it is intermingled with rales which are more or less coarse.

2. In circumscribed pneumonia, hemorrhagic infarctus, and pulmonary apoplexy, the fine or subcrepitant rale, often associated with those which are more or less coarse, denotes the presence of mucus or of blood within the bronchial tubes. The rales are localized in space, or in spaces, corresponding to the situation and extent of the affection.

3. During and shortly after a hemoptysis, fine rales limited to a particular situation are sometimes heard, proceeding from blood in the small bronchial tubes, and indicating the situation of the hemorrhage.

4. A purulent liquid admits of bubbling much more readily than mucus; hence, in cases of chronic bronchitis with an expectoration of pus, fine and coarse bronchial rales are more frequent than in acute bronchitis. Pus, also, may be present within bronchial tubes of small size, not as a product of bronchitis, but from the evacuation of an abscess of either the pulmonary

parenchyma, of the liver, or some other adjacent part, and from perforation of lung in some cases of empyema.

5. In the different stages of phthisis, moist bronchial rales are usually present. The liquid in the tubes, if the disease be advanced, is derived, in part, from associated bronchitis, and, in part, from liquefied tuberculous exudation. The bubbling sounds may be more or less coarse or fine, and both are often intermingled. Early in the disease, before softening of the exudation has taken place, fine bubbling, or the subcrepitant rale, limited to the summit of the chest, is an important diagnostic sign. This fine subcrepitant rale in early pulmonary tuberculosis is heard also, and not infrequently, at the tip of the lower lobes behind, in the inter-scapular regions. It belongs among the accessory physical signs on which the diagnosis may depend. Here the liquid is derived from a coexisting circumscribed bronchitis.

In cases of fibroid phthisis, or cirrhosis of lung, moist rales, coarse and fine, are generally more or less abundant and diffused over the whole, or the greater part, of the chest on the affected side.

In the foregoing account of the moist bronchial rales, the subcrepitant rale is not reckoned as a sign distinct from fine bubbling sounds. Inasmuch as the mechanism and the significance are the same, and it is not easy to draw a line of demarcation between the two, the distinction is unimportant. It is sufficient to bear in mind that very fine bubbling sounds are called subcrepitant, because they are somewhat analogous to the crepitant rale. The points which

distinguish the latter are, however, well marked, as will appear when the characters of that sign are considered. The term subcrepitant gives rise to confusion, and there is no advantage in retaining it as the name of a distinct sign. Very fine bubbling expresses more correctly the characters of the sign. The moist rales are often called mucous rales. This name is obviously inappropriate, since, not only are the sounds produced by other liquids than mucus, but other liquids are best suited for their production, especially in the large and medium-sized tubes.

The several varieties of the moist bronchial rales may be produced by the injection of a liquid in varying quantity into the bronchi of the lungs removed from the body of an aminal of sufficient size, *e. g.*, of the sheep or calf, and imitating respiration by means of bellows.

The moist bronchial rales, whether coarse or fine, vary in pitch accordingly as the lung surrounding the tubes in which they are produced is or is not solidified. If the lung be solidified, the pitch is high; if there be no solidification, the pitch is comparatively low. Thus the pitch of the rales is high in the second stage of pneumonia and in phthisis with considerable solidification, whereas the pitch is low in bronchitis and pulmonary edema. If, therefore, the respiratory sound be suppressed, it is easy to determine by the pitch of these rales whether the lung be solidified or not, and to judge measurably of the degree of solidification. Attention to the pitch in connection with these rales is sometimes of value in diagnosis.

DRY BRONCHIAL RALES

All adventitious sounds which are not moist, produced within the air-tubes below the trachea, are embraced under the name *dry bronchial rales.* The sounds are many and varied in character. They are often musical notes. Frequently they are suggestive of certain familiar sounds, such as the chirping of birds, the cry of a young animal, snoring in sleep, cooing of pigeons, humming of the mosquito, the note of the violoncello, etc. They are often heard at a distance, and characterized as wheezing sounds. An interrupted or clicking sound is not uncommon. All these varieties are practically unimportant, and it would be a needless refinement to consider particular varieties as distinct signs. The only distinction which it is desirable to make is into the sibilant and sonorous rales. This distinction is based on difference in pitch; sibilant rales are high, and sonorous rales are low in pitch. As a rule, the sibilant rales are produced in the small and the sonorous rales in the larger sized bronchial tubes. The sounds may accompany either inspiration or expiration, or both. The sibilant and sonorous rales are often intermingled. There may be sibilant rales with inspiration, and sonorous rales with expiration, within the same situation. Moreover, these rales are found often to vary from minute to minute, being at one instant sibilant, and at another sonorous. Students are likely to confound sonorous rales with bronchial breathing, and sometimes with friction-sounds.

The physical condition represented by the dry rales is diminished calibre of the air-tubes at certain points, and especially in consequence of spasm of the bronchial muscular fibres. The latter constitutes the essential pathological condition in a paroxysm of asthma; and in this affection the dry rales are always marked. Their diagnostic importance relates chiefly to asthma. Both sibilant and sonorous rales are present and diffused over the entire chest. Wheezing sounds with expiration are heard by the patient, and by others at a distance. A single paroxysm of asthma affords an opportunity for the student to observe all the varieties and fluctuations of these rales. Taken in connection with other signs and symptoms, the rales are pathognomonic of asthma.

More or less spasm of the bronchial muscular fibres occurs in certain cases of bronchitis, without being sufficiently great and extensive to give rise to a paroxysm of asthma, or even any embarrassment of respiration. Under these circumstances the rales are less marked and diffused. An asthmatic element may be said to enter, more or less, into these cases. Narrowing of bronchial tubes by tenacious mucus which gives rise to no bubbling sounds, and, perhaps, unequal swelling of the mucous membrane, may also occasion sibilant and sonorous rales.

Dry rales at the summit of the chest are not infrequent in cases of phthisis due to spasm, the presence of mucus, or to swelling of the mucous membrane. They are sometimes quite annoying to phthisical patients.

Clicking sounds are suggestive of the sudden separation of tenacious mucus from the walls of the bronchial tubes. These are sufficiently common in bronchitis and in phthisis.

VESICULAR OR CREPITANT RALE

This is the only vesicular rale. It is usually considered to be produced within the air-vesicles, but probably the terminal bronchial tubes or bronchioles participate in its production.

It is to be distinguished from very fine bubbling sounds, or the so-called subcrepitant rale. The points of distinction are as follows: The sounds are not moist but dry; they are crackling, not bubbling in character. They may be defined to be very fine, dry, crackling sounds. This point of difference is very distinctive. There are, however, other differential points. The crackling sounds are equal, whereas, fine bubbling sounds are unequal, that is, they give the impression of bubbles of unequal size. The crepitating sounds are heard at the end of the inspiratory act, and especially at the end of a forced inspiration, the subcrepitant rale, on the other hand, being heard often with or near the beginning of inspiration, and, perhaps, ceasing before the end of the inspiratory act. Another distinctive feature is the abrupt development of the crepitant rale; there is a shower of crackles, as it were, at the end of a forced inspiration. Finally, the rale is never heard in expiration. The apparent exceptions to this statement are instances in which the

crepitant and the subcrepitant rale are associated. This is not very infrequent, and, with a practical knowledge of the characters of each, it is by no means difficult to appreciate the combination of the two signs. In fact, the combination affords an excellent opportunity to illustrate the distinctive characters of each; the fine bubbling at or near the beginning of inspiration, followed by the fine crackling at the end of this act, and the former perhaps reproduced in the act of expiration.

There are various modes in which the crepitant rale may be imitated; for example, rubbing together a lock of hair near the ear, throwing fine salt upon live coal or into a heated vessel, igniting a train of gunpowder, and alternately pressing and separating the thumb and finger moistened with a solution of gum arabic and held near the ear. A perfect representation is afforded by squeezing a piece of an artificial preparation known as the India-rubber sponge, and observing the sound produced by the separation of the walls of the interstices when the piece expands from its elasticity. This preparation exemplifies the true mechanism of the sign as described, first, by the late Dr. Carr, of Canandaigua, N. Y., in an article published in the *American Journal of Medical Sciences,* in October, 1842.[1] Expansion of the lungs of the sheep or calf, after removal from the body, the stethoscope being applied to the lung-surface, gives, in certain situations, a well-marked crepitant rale.

[1] *Vide* article by the author in the New York Monthly Med. Jour. for February, 1869.

The crepitant rale is a common sign in pneumonia. It very rarely occurs in any other pathological connection. Of all respiratory signs, this is most entitled to be called pathognomonic. It belongs especially to the first stage of acute pneumonia. It is not invariably present, but it occurs in the majority of cases of acute pneumonia. In the second stage, or the stage of solidification, the rale generally disappears. It not infrequently is reproduced in the stage of resolution, and it is then called the returning crepitant rale. In the latter stage it is often found in combination with the subcrepitant rale. The practical value of this sign relates chiefly to the diagnosis of pneumonia.

It is stated that the crepitant rale is sometimes found in cases of pulmonary edema, and during or directly after an attack of hemoptysis. If it ever occur in these cases, the instances must be extremely rare. The statement is perhaps based on the occurrence of the subcrepitant, this being confounded with the crepitant rale. It occurs transiently under the following circumstances: A patient who has been confined for some time in bed, lying on the back, and much enfeebled with any disease, if suddenly raised to a sitting posture and auscultated, a crepitant rale is often found on the posterior aspect of the chest at the end of a forced inspiration. The rale disappears after a few forced inspirations. It is heard, not on one side only, but on both sides. The explanation is, that during the recumbent posture continued for some time, and the patient breathing feebly, enough

of the air-vesicles and bronchioles become agglutinated by means of a little sticky transudation to give rise to crackling sounds in a few forced inspirations. It may be of use to mention that if the stethoscope be applied to the anterior surface of a chest much covered with hair, the movements of the pectoral extremity of the instrument in the act of inspiration may produce a sound identical with the crepitant rale. This can be eliminated by applying oil or vaseline liberally over the hairy surface.

A crepitant rale at the summit of the chest, within a circumscribed space, is one of the accessory signs of phthisis. It denotes a circumscribed pneumonia which clinical experience shows to be generally secondary to phthisis; hence the diagnostic significance of the sign.

CAVERNOUS OR GURGLING RALE

A pulmonary cavity of considerable size, containing a certain quantity of liquid, and communicating freely with bronchial tubes, furnishes a rale which is characteristic. The character of the sound is expressed as fully as possible by the term gurgling. The sound is produced by large bubbling and the agitation of the liquid within the cavity. It may be compared to the sound produced by the boiling of a liquid in a flask or large test-tube. The sound is sometimes high pitched and amphoric, but generally it is low in pitch. It is heard with more or less intensity within a circumscribed space, almost invariably at or near the

summit of the chest; but if intense, the sound is diffused, and it may be sometimes heard at a distance. Its diagnostic importance relates to the advanced stage of phthisis. The rale is heard chiefly or exclusively in the act of inspiration. It may be produced by the act of coughing sometimes with greater intensity than by respiration.

PLEURAL RALES—FRICTION-SOUNDS—METALLIC TINKLING—SPLASHING

The signs embraced under the name pleural rales are: (1) Sounds produced by the rubbing together of the pleural surfaces, and hence called friction-sounds. (2) Metallic tinkling. (3) Splashing or succussion sounds.

Friction-Sounds.—Movements of the pleural surfaces upon each other take place in inspiration and expiration; but in health these movements occasion no sound. Sounds are produced when the surfaces are covered with a recent fibrinous exudation which prevents the normal continuous, unobstructed movements, and when the surfaces are roughened with dense lymph or other morbid products. The sounds are generally interrupted, that is, two, three, or more sounds occur during the act of inspiration or expiration, or during both acts. The intensity of the sounds varies much in different cases. A slight grazing sound only may be heard, or, on the other hand, the sounds may be so loud as to be heard by the patient, and by others at a distance. The character of the sounds

is variable. The slight rubbing or grazing character may be imitated by placing over the ear the palmar surface of one hand, and moving over its dorsal surface slowly the pulpy portion of a finger of the other hand. In some instances, however, the rough character of the sounds is expressed by such terms as rasping, grating, and creaking. In these instances the sounds denote density of the morbid product which roughens the pleural surfaces. In connection with very rough sounds, vibration of the walls of the chest, or fremitus, is sometimes perceived by palpation.

Aside from the character of the sounds as just stated, they are distinguished by their apparent nearness to the ear; they seem sometimes to be produced upon the surface of the chest. They are sometimes intensified by firm pressure of the stethoscope upon the chest. After a little practical knowledge of these sounds they can hardly be confounded with any other rales.

Pleuritic friction-sounds generally denote pleurisy. In cases of pleurisy with effusion, slight rubbing or grazing is sometimes heard before much liquid accumulates within the pleuritic cavity. The physical conditions, however, after the effusion has been removed, are much more favorable for the production of friction-sounds, and they are often now rough in character. They may be transient, or they may continue for a considerable period, their duration depending on the arrest of the movements of the pleural surfaces by means of either agglutination with lymph, or adhesion from the growth of areolar tissue.

Pleuritic friction-sounds occur not infrequently in cases of pneumonia, denoting, in this connection. coexisting pleurisy.

Slight rubbing or grazing at the summit of the chest is one of the accessory signs of phthisis. It denotes a circumscribed, dry pleurisy, which, as clinical experience shows, is generally secondary to phthisis, and hence the diagnostic significance of the sign.

In the foregoing instances in which friction-sounds are stated to occur, their significance relates to pleurisy. In some rare instances the sounds are produced by miliary tubercles, or neoplastic nodules projecting beyond the plane of the visceral pleural surface, without pleuritic inflammation.

Metallic Tinkling.—This is a vocal as well as a respiratory sign. It is also produced by acts of coughing, and sometimes by the act of deglutition. The name expresses the distinctive character of the sign. It consists in a series of tinkling sounds of a high-pitched, silvery, or metallic tone. The number of sounds varies from a single sound to two, three, or more sounds, during an act of either inspiration or expiration. This sign may be imitated in various ways by means of an India-rubber bag of considerable size. Forcing a liquid into the bag with Davidson's syringe, tapping the bag with the finger, or shaking it, will produce tinkling sounds. The best mode of artificial representation of the sign is to connect the bag with a flexible tube, the latter containing a few drops of liquid, and blowing into the tube so as to produce bubbles at the communication of the tube

with the bag. In this latter experiment it is not necessary that the bag contain any liquid. It occurs irregularly, that is, it is not present in every act of breathing, but is heard at variable intervals. It may sometimes be produced by forced, when it is not heard in tranquil, breathing. It can only be confounded with tinkling sounds sometimes produced within the stomach. The latter, however, are easily discriminated by their situation, and the absence of associated signs denoting the affections of the chest in which the sign occurs.

Metallic tinkling is the sign of pneumothorax with perforation of lung. In the great majority of the cases in which it is found, it is diagnostic of this affection. It is, however, always associated with other physical signs corroborative of the diagnosis.

It is a rare sign, in cases of phthisis, of a large pulmonary cavity, the conditions for its production being analogous to those in pneumo-hydrothorax, namely, a space of considerable size containing air, the space communicating with bronchial tubes.

Splashing, or Succussion Sounds.—This sign is produced by succussion, which is reckoned as one of the different modes of physical exploration. Sounds thus produced are not infrequently heard at some distance; generally, however, succussion is practised while the ear is applied to the chest, so that properly enough the sign may be embraced among the auscultatory signs, although not produced by respiration.

Splashing is pathognomonic of either pneumo-hydrothorax or pneumo-pyothorax. It is especially

valuable as a sign of these affections because it is almost invariably available. The instances are extremely few in which the sign is wanting when air and liquid are contained in the pleural cavity. It is obtained by jerking the body of the patient with a quick, somewhat forcible movement, the ear being very near to, or in contact with, the chest.

The sound is like that produced when a bottle partially filled with liquid is shaken. The sound is often high-pitched and amphoric in quality. The only liability to error is in confounding with this sign, splashing produced within the stomach. Attention to other signs will always protect against this error.

Indeterminate Rales.—Under this head may be embraced some sounds sufficiently recognizable, but indeterminate as regards the rationale of their production and the physical conditions which they represent. They may be designated crumpling and crackling sounds. The former are probably due to pleuritic rubbing, and the latter to the separation of some slightly adherent air-vesicles or bronchioles. Their diagnostic value relates only to the early stage of phthisis. In conjunction with other signs, any indeterminate rale, if limited to the summit of the chest, and especially to one side, has some weight in the diagnosis. Crumpling and crackling sounds, however, are not uncommon in healthy persons at the end of forced inspiration. The fact of their presence at both summits, and the absence of other morbid signs, are the grounds for not considering them as

evidence of disease. They are found in health, especially if the binaural stethoscope be employed. Their diagnostic significance, thus, depends on limitation to the summit of the chest on one side, and association with other signs pointing to incipient phthisis.

THE VOCAL SIGNS OF DISEASE

The vocal signs of disease, with the exception of metallic tinkling, which is a vocal as well as respiratory sign, may all be considered as abnormal modifications of the normal vocal resonance and of the normal bronchial whisper. The student must, therefore, be familiar with the distinctive characters of these two normal signs before he is prepared to enter upon the study of the abnormal modifications (*vide* pages 99 and 105). We must bear in mind the facts which have been presented in relation to the normal vocal fremitus (*vide* page 100). The rules given for auscultation of the voice are also to be observed (*vide* page 89). Embracing the abormal modifications of the loud voice, the whisper and fremitus, the following are the signs to be considered: Bronchophony; Whispering Bronchophony; Egophony; Increased Vocal Resonance; Increased Bronchial Whisper; Cavernous Whisper; Pectoriloquy; Amphoric Voice or Echo; Diminished and Suppressed Vocal Resonance; Diminished and Suppressed Vocal Fremitus, and Metallic Tinkling.

BRONCHOPHONY

Bronchophony has the same import as bronchial or tubular respiration. Like the latter sign, it represents complete or considerable solidification of lung. Generally the two signs are associated, but either may be present without the other.

The characters which are distinctive of bronchophony, as compared with normal vocal resonance, are these: The vocal sound seems concentrated, in most cases near the ear, and the pitch is more or less raised. These characters are in contrast with the diffusion, distance, and lowness of pitch of the normal vocal resonance. The intensity of the sound is variable; it may be greater or less than the intensity of the normal resonance. A concentrated, high-pitched sound, however feeble, is not less a sign of complete or considerable solidification of lung, that is, it is not less bronchophony, than when the sound is intense.

Vocal fremitus is always to be discriminated from vocal resonance. The fremitus associated with bronchophony may, or may not, be greater than the fremitus of health. Not infrequently the fremitus is less than in health.

It is to be borne in mind that in some healthy persons bronchophony exists at the summit of the chest, especially on the right side, over the primary bronchus. Existing in this situation, it may not be abnormal.

Representing complete or considerable solidifica-

tion of lung, this sign occurs in the different affections in which bronchial or tubular respiration has been seen to occur (*vide* page 118), namely, lobar pneumonia, phthisis, chronic or fibroid pneumonia, condensation of lung from either pleuritic effusion, the accumulation of air in the pleural cavity or the pressure of a tumor, collapse of pulmonary lobules, coagulation of blood within the air-vesicles, and neoplasm of lung.

For the production of bronchophony, a less degree of solidification is requisite than for the production of bronchial or tubular respiration. Hence, bronchophony may be associated with a broncho-vesicular, as well as with a purely bronchial, respiration. This is illustrated in the resolving stage of pneumonia. When resolution has progressed sufficiently for the bronchial to give place to the broncho-vesicular respiration, well-marked bronchophony is often found to continue, ceasing at a later period in the resolving stage.

The apparent nearness to the ear of the vocal sound in bronchophony is wanting if a certain quantity of liquid intervene between the solidified lung and the walls of the chest at the situation auscultated. The voice under these conditions seems to be more or less distant. This difference is readily appreciated. With this apparent distance of the bronchophonic voice in some instances is associated the modification which is characteristic of another sign—namely, egophony.

WHISPERING BRONCHOPHONY

The characters of this sign correspond to those of the expiratory sound in the bronchial or tubular respiration (*vide* page 117). The sound is more or less intensified, high in pitch, and tubular in quality. If the patient pronounce numerals in a forced whis er, the characters are generally more marked than in the expiratory sound in forced breathing. The significance of this sign is the same as that of the bronchial or tubular respiration, and of bronchophony with the loud voice.

EGOPHONY

This sign is a modification of bronchophony. As regards concentration and pitch, it has the characters of bronchophony, the distinctive features being, apparent distance from the ear, the tremulousness or a bleating tone. From the latter the name is derived, the term signifying the cry of the goat. The characters which distinguish the sign from bronchophony are readily enough appreciated, and it represents a physical condition added to solidification of lung. This physical condition is the presence of liquid effusion. The sign is rarely present in cases of large effusion. It occurs usually when the chest is about half filled with liquid, and the lung at the level of the liquid is sufficiently condensed to give rise to bronchophony. This condition, under these circumstances, involve agglutination of lung above the portion condensed

by pressure. The sign also sometimes occurs in cases of pleuro-pneumonia, the solidification in these cases being due to pneumonic exudation. As a sign of liquid effusion it possesses diagnostic value, although, owing to the fact that the existence of effusion is easily determined by other signs, it may be said to be superfluous. When the person examined speaks with the teeth approximated, bronchophony has somewhat of the character of egophony.

INCREASED VOCAL RESONANCE AND FREMITUS

The distinctive character of this sign is an increase of the intensity of the resonance without notable change in other respects. The resonance may be more or less intensified, but it is distant, diffused, and comparatively low in pitch; in other words, the characters distinctive of bronchophony are wanting. The differential points between bronchophony and increased resonance should be clearly apprehended, bearing in mind that the intensity of the sound in bronchophony may, or may not, be greater than the normal resonance.

Increased vocal resonance occurs when the lung is solidified, the solidification not sufficient in degree to produce bronchophony. Lung slightly or moderately solidified gives rise to an increase of the intensity of the resonance of the voice; if the solidification become considerable or complete, bronchophony takes the place of the simple increase of intensity. Thus,

at an early period in pneumonia, increased vocal resonance precedes bronchophony; and in the stage of resolution the reverse of this takes place—namely, increased vocal resonance follows bronchophony, the latter ceasing when resolution has progressed to a certain extent.

Contrary to what would perhaps be anticipated in the instances just cited, the intensity of the sound when bronchophony is present may be not only not increased, but diminished below that of health; that is, in the first stage of pneumonia the increased intensity may cease when bronchophony occurs, and return when bronchophony disappears.

Increase of the vocal resonance occurs in connection with pulmonary cavities. Over a cavity of considerable size, situated near the superficies of the lung, the vocal resonance is sometimes extremely intense, without any bronchophonic characters. The latter, if present, denote considerable solidification either around the cavity, or between it and the walls of the chest. From the presence or the absence of bronchophonic characters with greatly increased intensity of resonance, the auscultator can judge whether the cavity be, or be not, in proximity to considerable solidification of lung.

Irrespective of the cavernous stage of phthisis, the sign is of diagnostic importance in the different affections which involve moderate or slight solidification of lung—namely, pneumonia early in the disease and in the stage of resolution, phthisis, over the compressed lung in pleurisy with moderate effusion, collapse of

pulmonary lobules, hemorrhagic infarctus, and neoplasms of lung. Into the diagnosis of all these affections, both bronchophony and increased vocal resonance enter; the former when solidification is considerable or complete, and the latter when it is slight or moderate. Increased vocal resonance is especially valuable in the diagnosis of early or incipient phthisis. An abnormal resonance, however slight, at the summit of the chest on one side, is an important sign in that affection. In determining an abnormal resonance on the right side, either of the summit or elsewhere, allowance must always be made for the normally greater resonance on this side.

Increased vocal resonance has the same import as broncho-vesicular respiration. These two signs, however, are not always in the same proportion; that is, the characters of the latter may be marked, out of proportion to the amount of the increase of the vocal resonance, and *vice versa*.

Increased vocal fremitus generally accompanies increased vocal resonance, and it denotes solidification of lung. Fremitus, however, and resonance are not always in equal proportion, that is, either may be increased more than the other. An increased fremitus is sometimes of value in the diagnosis of phthisis. The greater fremitus on the right side of the chest is always to be borne in mind, and due allowance is to be made for this disparity in determining that the fremitus is increased.

INCREASED BRONCHIAL WHISPER

The significance of this sign is the same as that of increased vocal resonance and the broncho-vesicular respiration; it represents the same physical condition as the two latter signs—namely, solidification of lung, greater or less, but below the degree requisite to give rise to bronchophony and bronchial respiration. Its diagnostic application is, therefore, involved in the same pulmonary affections.

The characters of the sign are those which belong to the expiratory sound in the broncho-vesicular respiration. They consist, therefore, of increase of intensity, a quality more or less tubular, and the pitch raised, these modifications of the normal expiratory sound varying in degree, between the slightest appreciable morbid change, and a close approximation to the bronchophonic whisper. The modifications in degree correspond to the degree of solidification. To appreciate the characters of this sign, it must be studied in comparison with those of the normal bronchial whisper in different portions of the chest. The most important of the diagnostic applications of the sign is in cases of phthisis in its early stage. In this application, the points of normal disparity between the two sides of the chest at the summit are to be borne in mind, and due allowance made for them (*vide* page 107).

A greater intensity of the bronchial whisper at the right than at the left summit is not evidence of dis-

ease; but greater intensity at the left summit is always abnormal. As a rule, the pitch of the normal bronchial whisper at the left is higher than that at the right summit; if, therefore, with a greater intensity of the whisper at the right summit it be a matter of doubt whether it denote diseases or not, when the pitch is higher at this summit it is to be considered as morbid.

Cavernous Whisper.—The characters distinctive of the cavernous whisper are those of the expiratory sound in the cavernous respiration—namely, lowness of pitch, and the quality blowing, that is, non-tubular. The intensity of the sound is variable. It is limited to a circumscribed space corresponding to the situation and size of the cavity. Not infrequently the characters of the sign are brought into contrast with those of whispering bronchophony, or increased bronchial whisper, these latter signs existing in close proximity, and representing solidification of lung in the immediate neighborhood of the cavity. The diagnostic application of this sign is chiefly to advanced phthisis.

Pectoriloquy.—In pectoriloquy, not merely the voice, but the speech, is transmitted through the chest; the auscultator recognizes words uttered by the patient.

The student, however, must not expect to be able to carry on a conversation with the patient by means of the stethoscope. Often single words only can be recognized. To make sure that these are transmitted through the chest, care must be taken to exclude their direct transmission from the patient's mouth, and the auscultator should not know beforehand the

words which are to be spoken. If these rules be not observed, the auscultator may err in supposing that the words are transmitted through the chest. When auscultation is practised with one ear, the other should be closed.

The speech with either the loud or the whispered voice may be transmitted, the latter, distinguished as whispering pectoriloquy, being much more frequent than the former; moreover, in determining whispering pectoriloquy, there is less liability to error in mistaking the perception of words coming directly from the mouth for the transmission through the chest. In the production of this sign much depends on the distinctness with which words are articulated by the patient. Normal pectoriloquy at the anterior superior portion of the chest is sometimes observed.

Pectoriloquy belongs among the cavernous signs; but it is by no means exclusively the sign of a cavity; the speech may also be transmitted by solidified lung. It is easy to determine in any case whether the sign denotes a cavity or solidified lung. If, with transmitted speech, the voice have the characters of bronchophony, the sign represents solidification of lung; if, on the other hand, the characters of bronchophony be wanting, the sign represents a cavity.

These statements apply equally to the loud and to the whispered voice. Of course, associated signs will be likely to show whether a cavity exists or not. It is to be added that a cavity and solidification of lung, existing together, may conjointly be concerned in the production of the sign.

Amphoric Voice or Echo.—This sign is identical in character with amphoric respiration, with which it is usually associated (*vide* page 127). The amphoric intonation may accompany the loud voice and the whisper; generally, it is more appreciable or marked with the latter. Its significance is the same as that of amphoric respiration. As a rule, it represents the conditions in pneumothorax—namely, a large space filled with air and perforation of lung. In this affection it is associated with other signs which suffice for a prompt and positive diagnosis. It is not invariably found in pneumothorax, and it may be present in a case at one time and wanting another time; its production being dependent on the perforation being above the level of liquid, if the latter exist, and on the bronchial tubes leading to the perforation being unobstructed. When not associated with other signs which are diagnostic of pneumothorax, it denotes a phthisical cavity of considerable size. It is not infrequently a sign of a phthisical cavity with rigid walls and communicating freely with bronchial tubes. It has this significance whenever pneumothorax can be excluded; and the associated signs in the latter affections are such that its exclusion is always practicable.

The amphoric sound sometimes is observed to follow the oral voice; hence, the name amphoric echo.

Diminished and Suppressed Vocal Resonance.—Diminution and suppression of the normal vocal resonance occur especially when the pleural cavity contains either liquid or air. Whenever the lungs are not

in contact with the walls of the chest, the vocal resonance, as a rule, is either notably lessened or wanting. The sign is, therefore, of value in diagnosis in cases of pleurisy with effusion, empyema, hydrothorax, and pneumothorax. When the pleural cavity is partially filled with liquid, there is diminution or suppression of the resonance from the level of the liquid downward; and generally, just above the level of the liquid, the resonance is increased, owing to condensation of the lung. The sign is well illustrated by the contrast in such cases above and below the level of the liquid. As a rule, the changes of the level of the liquid with changes in position of the body may be as well demonstrated by means of vocal resonance as by percussion. Exceptionally, however, this rule is not available.

The practical importance of diminished, and suppressed, vocal resonance relates chiefly to the diagnosis of the affections just named. In this application, however, the associated signs must be taken into account. The vocal resonance may be diminished, or suppressed, when the lung is completely solidified in the second stage of pneumonia, when the consolidation involves the bronchi resulting in their obstruction; also in pulmonary edema, and over the site of an intrathoracic tumor.

If the vocal resonance be normal, that is, neither increased nor diminished, we are warranted in excluding all the affections which have been named; the exceptional instances are so rare that, practically, they may be disregarded.

Diminished vocal resonance may be found over a pulmonary abscess before the pus is evacuated, and over a cavity filled with liquid. The sign is then limited to a circumscribed space. Obstruction of a bronchial tube diminishes resonance in so far as the column of air is a medium for the conduction of vocal sound.

In emphysema and in chronic pleurisy with marked thickening of the parietal or visceral pleura, or of both, due to organized fibrin and connective tissue, we find marked instances of diminished and suppressed vocal resonance.

The normal disparity between the two sides of the chest is to be borne in mind with reference to diminished or suppressed, as well as to increased, vocal resonance; otherwise the relative feebleness of the resonance on the left side in health might be considered to be morbid. The normally greater resonance on the right side renders it easier to determine a morbid diminution on this than on the left side.

If the stethoscope be firmly pressed upon the lower part of the chest wall, especially in front, above the lower border of the lung there may be a great suppression or even total absence of vocal resonance. The vibration of the chest wall, particularly in the lower part, is easily interfered with by a too firm pressure of the stethoscope bell upon the chest.

Diminished and Suppressed Vocal Fremitus. — This tactile sensation, which is appreciable in auscultation, as a rule, is, on the one hand, increased, and, on the other hand, diminished or suppressed, under

the same physical conditions which occasion corresponding modifications of the vocal resonance. Diminished or suppressed vocal fremitus, therefore, has the same diagnostic significance as diminished or suppressed vocal resonance. Usually the abnormal modifications of resonance and fremitus go together but either may be out of proportion to the other. The signs relating to fremitus thus corroborate those relating to resonance. The former may be marked when the latter admit of doubt. Diminished or suppressed fremitus is valuable in the diagnosis of pleurisy with effusion, empyema, hydrothorax, pneumothorax, emphysema, and chronic thickened pleura. It is, however, to be noted that in exceptional instances the fremitus persists over the site of liquid within the chest.

With regard to vocal fremitus, as to vocal resonance, it is essenital to take cognizance of the normal disparity between the two sides of the chest, the greater relative fremitus, on the right side, as a rule, being no less marked than the relatively greater resonance on that side.

Metallic Tinkling.—This sign has the same characters when it accompanies either the loud or whispered voice, as when it is heard with respiration, and, of course, it has the same significance (*vide* page 149). It may be more marked with acts of speaking than with the respiratory acts.

SIGNS OBTAINED BY ACTS OF COUGHING OR TUSSIVE SIGNS

Acts of coughing may be made subservient to auscultation of respiratory sounds in two ways: (1) By the removal of temporary obstruction from the accumulation of mucus within bronchial tubes. If the respiratory murmur be diminished or suppressed over a portion or the whole of one side of the chest, sometimes an act of coughing effects dislodgement of a mass of mucus from either a primary bronchus or one of its subdivisions, and the normal murmur is at once restored. The dependence of the morbid sign upon a temporary obstruction is thus demonstrated. (2) By an act of coughing more air is expelled than by an ordinary expiration, and in the following inspiration the vesicles have a wider range of expansion, giving rise to a proportionately loud inspiratory sound; hence, the characters of this sound are pronounced and can be better studied. For these two objects it is often advisable to request the patient to cough with a certain degree of force.

This procedure, of having the patient cough at the end of an expiratory act, and immediately breathe in freely, is of particular advantage in eliciting the elusive fine crepitations at the apices of the upper or lower lobes in suspected or early pulmonary tuberculosis.

Acts of coughing, moreover, give rise to auscultatory signs which have their analogues in signs obtained by respiration and the voice. These tussive signs

are of less value than the respiratory and vocal signs, and in most cases, owing to the latter being sufficient for diagnosis, they may be said to be superfluous; nevertheless, they may be observed sometimes with advantage. When the conditions are present which are represented by bronchial respiration, bronchophony and the bronchophonic whisper, sounds are obtained which correspond to these in their characters. The cough is then said to be bronchial. With the stethoscope applied over an empty cavity of some size, situated near the surface of the lung, the ear receives with acts of coughing a concussion or shock which is sometimes so forcible as to be painful. This corresponds to an intense vocal resonance. Limited to a circumscribed space, it is a highly significant cavernous sign. It may be present when the cavernous respiration is wanting. A low-pitched blowing sound corresponds to the expiratory sound in the cavernous respiration and the cavernous whisper. An amphoric intonation may be heard with acts of coughing, which corresponds to amphoric respiration and amphoric voice. This sign is sometimes more marked with cough than with the breathing and voice. Cavernous gurgling may also be obtained more distinctly with cough than with respiration. Finally, metallic tinkling not infrequently accompanies acts of coughing.

CHAPTER VI

THE PHYSICAL DIAGNOSIS OF DISEASES OF THE RESPIRATORY ORGANS

Affections of the larynx and trachea—Bronchitis seated in large bronchial tubes—Bronchitis seated in small bronchial tubes, or capillary bronchitis—Collapse of pulmonary lobules—Lobular pneumonia—Asthma—Pulmonary or vesicular emphysema—Pleurisy, acute and chronic—Empyema—Hydrothorax—Pneumothorax—Pneumo-hydrothorax—Pneumo-pyothorax—Acute lobar pneumonia—Circumscribed pneumonia—Embolic pneumonia—Hemorrhagic infarctus—Pulmonary apoplexy—Pulmonary gangrene—Pulmonary edema—Neoplasms of lung—Tumor within the chest—Acute miliary tuberculosis—Pulmonary phthisis—Fibroid phthisis, interstitial pneumonia, or cirrhosis of lung—Diaphragmatic hernia.

In the preceding chapters the physical conditions incident to the morbid changes occurring in the affections of the respiratory organs have been enumerated, and the physical signs, obtained by percussion and auscultation, representing these conditions, have been considered, severally, as regards their distinctive characters and their significance. The object of this chapter is to group the physical conditions embraced in the different diseases of the respiratory system respectively, together with the representative signs on which rests the physical diagnosis of each of the diseases. The scope of this manual is limited to the physical diagnosis of these affections; but the fact is

not to be lost sight of that in practical medicine physical signs are not to be disassociated from symptoms and pathological laws. An exclusive reliance on physical signs would lead to errors in diagnosis, although, doubtless, errors more important and more frequent necessarily occur when the practitioner ignores percussion and auscultation. The signs furnished by percussion and auscultation only have been thus far considered, but in grouping these in this chapter, signs obtained by other methods of physical exploration will be embraced in so far as they enter into the diagnosis of the different diseases of the respiratory system. These different diseases will be taken up separately with the exception of those seated in the larynx and trachea. With reference to physical signs, the laryngeal and tracheal affections may be considered collectively.

AFFECTIONS OF THE LARYNX AND TRACHEA

The physical signs referable to the chest in diseases of the larynx and trachea, denote more or less obstruction to the free passage of air through these sections of the air-tubes. The obstruction in the different diseases involves different pathological conditions. Spasm of the glottis is one of these conditions, constituting the affections known as laryngismus stridulus and spasmodic croup, occurring also as a pathological element in laryngitis, and sometimes in connection with aneurism, or a tumor of some kind, involving the recurrent laryngeal nerve. Another

pathological condition is the opposite of this, namely, paralysis of the muscles of the glottis, the vocal chords remaining flaccid, and approximating during inspiration. Other pathological conditions are, edema of the glottis, swelling of the membrane at the glottis in laryngitis, together with, in the adult, submucous infiltration, diphtheritic exudation, cicatrization of ulcers, morbid growths, and the presence of foreign bodies.

In the affections involving the foregoing pathological conditions, percussion and auscultation are of use: (1) By enabling the physician to exclude all diseases within the chest. The absence of signs showing the existence of pulmonary diseases renders it certain that the symptoms denoting embarrassment of respiration are referable to the larynx or trachea. (2) By means of auscultation the amount of obstruction may be determined more accurately than by the subjective symptoms. The amount of obstruction is represented by a proportionate weakening of the vesicular murmur. This is more reliable as regards determining a dangerous amount of obstruction than the sense of the want of air or the suffering of the patient. The degree of diminution of the vesicular murmur is determinable with the more accuracy, the better the auscultator is acquainted with the normal intensity, that is, the intensity prior to the occurrence of obstruction. With this knowledge, the weakening of the murmur is a correct criterion of the amount of obstruction. In all the pathological conditions named, the respiratory murmur is more or less diminished in

intensity on both sides of the chest; there are no signs obtained by percussion, nor do vocal resonance or fremitus offer anything distinctive.

In cases of considerable or great obstruction during inspiration, inspection furnishes marked signs. The expansion of the chest on both sides is restricted, the lower part of the chest is contracted in the act of inspiration, and in this act the soft parts above the clavicles are depressed. The contrast between these abnormal movements and the normal thoracic movements of the patient is striking and distinctive.

An important application of auscultation is the localization of a foreign body which has been inhaled. If the vesicular murmur on both sides be more or less weakened, the foreign body must be situated in either the larynx or the trachea. If, on the other hand, the vesicular murmur be weakened or suppressed on one side, and increased on the other side, the body is lodged in a primary bronchus. The importance of this application of auscultation before opening the trachea to remove a foreign body is sufficiently obvious. The situation of a foreign body may be changed from one bronchus to the other by an act of coughing, even after an operation has been commenced; this is, of course, at once determinable by auscultation.

By the application of *x*-ray examination, especially when combined with stereoscopic study of the plates, invaluable information is to be obtained as to the location of foreign bodies within the air-passages. When available it should be used to supplement auscultation and percussion.

BRONCHITIS SEATED IN LARGE BRONCHIAL TUBES

In bronchitis, either acute or chronic, as it is ordinarily presented in practice, the inflammation is seated in the large bronchial tubes, in many cases probably not extending beyond the primary and secondary bronchi. The physical conditions are, more or less swelling of the mucous membrane, this, however, not being sufficient to occasion any notable obstruction to the free passage of air, and the presence, in different cases, in greater or less quantity, of mucus, muco-purulent matter, pure pus, and serum.

The physical diagnosis involves negative rather than positive points; in other words, the diseases from which bronchitis is to be differentiated are excluded by the absence of their diagnostic signs. These diseases are pneumonia, pleurisy, and phthisis. Each of these is characterized by the presence of signs, the absence of which warrants its exclusion. In bronchitis there is no disparity between the two sides of the chest in the resonance obtained by percussion, nor in vocal resonance, the bronchial whisper, and fremitus. The swelling of the bronchial mucous membrane may cause some diminution of the intensity of the vesicular murmur, but as the affection is bilateral, and the bronchial tubes on each side are affected equally, both in degree and extent, no appreciable disparity in this respect between the two sides is caused by this physical condition. Weakening or

suppression of the murmur over an area greater or less, may be caused by bronchial obstruction from a plug of mucus. This obstruction is sometimes removed by an act of expectoration, after which the murmur is found to have returned, or to have regained its normal intensity.

The foregoing points, taken in connection with the history and symptoms, suffice for the diagnosis. Signs due directly to the disease represent diminished calibre of the tubes at certain points from swelling of the membrane, adhesive mucus, and spasm of bronchial muscular fibres. These signs are the dry bronchial rales. They are rarely prominent, and are oftener absent than present, if the bronchitis be unaccompanied by asthma; hence, they are of little value in the diagnosis. Other signs are the bubbling sounds or the moist bronchial rales. In acute bronchitis these are oftener absent than present. They occur when liquid morbid products within the tubes are unusually abundant, or when the removal of these is with difficulty effected by expectoration in consequence of muscular debility or other causes. These rales are abundant and loud in proportion as the liquid within the tubes is either muco-purulent, purulent, or serous in character. They are more or less coarse in proportion to the size of the tubes in which the bubbling takes place.

The diagnostic points, negative and positive, which have been stated, are alike applicable to acute and chronic bronchitis, it being, of course, understood that the affection is primary, that is, not secondary to some other pulmonary disease.

If the bronchitis be unaccompained by solidification of lung, the moist rales which may be present are low in pitch. The pitch is raised if there be solidified lung surrounding or adjacent to the tubes in which the moist rales are produced.

BRONCHITIS SEATED IN SMALL BRONCHIAL TUBES —CAPILLARY BRONCHITIS—COLLAPSE OF PULMONARY LOBULES—LOBULAR PNEUMONIA

Inflammation extending into the small tubes (capillary bronchitis) occasions in these the same physical conditions which are incident to bronchitis affecting tubes of large size, namely, swelling of the membrane, and the presence of liquid morbid products. The latter are not as easily removed by expectoration as when they are within large tubes, and, therefore, they are constantly present in greater or less quantity. These conditions in small tubes involve obstruction to the passage of air to and from the air-vesicles; hence, the vast difference as regards the symptoms, the suffering, and the danger. The affection is bilateral, a fact greatly enhancing the gravity of the affection. An incidental physical condition is solidification, generally in disseminated portions of lung, the latter varying in number and size. These portions of solidified lung denote either collapse of pulmonary lobules or lobular pneumonia, or both in conjunction. To this incidental affection, German writers apply the name "catarrhal pneumonia." Of course, any discussion of pathological questions suggested by these

names would be here out of place. With reference to diagnosis it is to be borne in mind that the solidified portions of lung in cases of bronchitis seated in small tubes are especially situated in the lower lobes. Another incidental physical condition is temporary dilatation of the air-cells, or vesicular emphysema, seated in the upper lobes. Both of these incidental conditions are bilateral, like the bronchitis with which they are connected. Collapse of pulmonary lobules, or lobular pneumonia, or both, and emphysema occur in only a certain proportion of the cases of bronchitis seated in small tubes. The signs, therefore, admit of a division into those which relate (1) to the bronchitis, and (2) to these incidental affections. With reference to the diagnosis, the fact is to be borne in mind that bronchitis seated in small tubes occurs chiefly in children and the aged.

The physical diagnosis of bronchitis seated in small tubes rests on negative points, together with a positive sign which is uniformly present. This sign is the fine moist bronchial or the so-called subcrepitant rale, present on both sides and diffused over the chest. The bubbling sounds are to be distinguished from the fine dry crackling sounds or the crepitant rale, to the characters of which the former in some measure approximate.

The bronchitis gives rise neither to dulness on percussion, nor to any notable change in vocal resonance, or fremitus. The respiratory murmur, if not obscured by rales, is weakened on both sides. Irrespective of being drowned by rales, it may be sup-

pressed by the amount of bronchial obstruction. These are the negative points in the diagnosis. In pulmonary edema, fine moist bronchial rales are present on both sides, but in this affection there is notable dulness on percussion, and the affection occurs in certain pathological connections—namely, with mitral stenosis, and disease of the kidneys. Acute tuberculosis may present the moist bronchial rales with the negative points which, in connection with symptoms, characterize bronchitis seated in the small tubes. The differentiation is to be based on differences pertaining to the history and duration, together with the age of the patient.

The coexistence of the incidental affections, namely, collapse of pulmonary lobules, or lobular pneumonia, and vicarious emphysema, occasions additional signs. If the solidified portions of lung be considerable in either number or size, there will be dulness on percussion in circumscribed situations on the posterior aspect of the chest. This will be found on both sides, but perhaps more marked on one side. Broncho-vesicular or the bronchial respiration may be present, together with the vocal signs of solidification, namely, either increased vocal resonance, or bronchophony, and increased vocal fremitus. The moist rales produced within solidified portions of lung are high in pitch, whereas, if solidification do not exist, these rales are comparatively low in pitch. The existence of solidification at any point may be determined by the pitch of the rales, as well as by the foregoing respiratory and vocal signs.

When there are emphysematous lobules on the anterior aspect of the chest in the upper and middle regions, on both sides, the resonance on percussion is vesiculo-tympanitic, the respiratory murmur weakened or suppressed, and the rhythm altered—in short, the combination of signs which will be stated under the head of emphysema.

In the cases in which the bronchitis occasions great obstruction in the small tubes, and, still more, if collapse of lobules, or lobular pneumonia and vicarious emphysema occur, important signs are obtained by inspection. The anterior portion of the chest remains expanded, and retraction of the lower part of the chest takes place in the acts of inspiration.

ASTHMA

The pathologico-physical condition in a paroxysm of asthma, is obstruction in the small bronchial tubes, attributable to spasm of the bronchial muscular fibres. With this condition is associated a temporary vesicular emphysema, which exists often as a persistent affection in persons who are subject to asthma. If the emphysematous condition already exist it is increased during the paroxysm of asthma. Bronchitis generally coexists, either as a transient or a chronic affection. In an asthmatic paroxysm, therefore, there are present the signs which are proper to asthma, together with those of emphysema, and the associated bronchitis may also occasion additional signs.

The physical diagnosis of asthma, like that of bronchitis seated in small tubes, is based on negative points taken in connection with a sign which is invariably present, namely, dry bronchial rales. These rales are more or less intense, and they are diffused over the entire chest. They are generally heard at a distance. The sibilant and sonorous varieties are mingled, and they are constantly changing as regards the character of the sounds.

The negative points are the same as in capillary bronchitis, namely, absence of dulness on percussion, vocal resonance and fremitus also being unaltered. Asthma and bronchitis seated in small tubes agree in the fact that obstruction is the important physical condition. A highly important differential point relates to the frequency of the respirations; they are much increased in frequency in capillary bronchitis, and not in asthma. Pathologically they differ essentially in the fact that the obstruction is due in the latter affection to bronchial inflammation, and in the former to spasm. The two affections differ in the signs representing these different conditions—fine moist bronchial rales existing in one, and loud diffused dry bronchial rales existing in the other.

Taking the difference, as regards the positive physical signs, in connection with the history and symptoms, the differentiation of the two affections may be made without difficulty.

The signs which relate to the associated emphysematous condition are those which are diagnostic of this condition, existing irrespective of asthma;

and the physical diagnosis of emphysema will be next considered. Coexisting bronchitis may give rise to moist bronchial rales more or less coarse. These are, however, often wanting, and they are rarely marked during paroxysms of asthma. When present in this pathological connection, they are low in pitch, denoting the absence of solidification of lung.

PULMONARY OR VESICULAR EMPHYSEMA

This affection, as a rule, is seated exclusively or chiefly in the upper lobes. When it is lobar, in contradistinction from the emphysema existing in comparatively a few disseminated or isolated portions of lung, increase in volume of the affected lobes is an important physical condition standing in relation to certain signs. Diminished range of expansion with acts of inspiration is another physical condition; the affected lobes are in a permanent state of expansion approximating to that at the end of the inspiratory act. It follows from these conditions that the amount of air is in excess of the normal proportion to the solids and liquids in the affected lobes. Both lungs are affected, that is, the affection is bilateral. In the great majority of cases chronic bronchitis coexists, and patients affected with emphysema are often, but by no means invariably, subject to paroxysms of asthma. Not infrequently an asthmatic element, with or without pronounced paroxysms of asthma, exists much of the time in connection with emphysema. The emphy-

sematous condition, as a rule, with few exceptions, is greater in the upper lobe of the left, than of the right lung. A rare condition, which is generally included under the name emphysema, differs materially from the ordinary form of this affection. This condition is that also known as senile atrophy of the lungs. The volume of the lungs is not increased in this variety of emphysema, the proportion of air over the solids is, however, in excess, owing to the diminution of the latter from atrophy.

The diagnostic evidence obtained by percussion is quite distinctive of lobar emphysema. The resonance over the upper and middle regions of the chest on both sides is vesiculo-tympanitic, that is, the intensity of the resonance is abnormally increased, the quality is a combination of the vesicular and tympanitic, and the pitch is more or less raised. Owing to the fact that the emphysema is greater on the left than on the right side, the vesiculo-tympanitic resonance is more marked on the left side. The difference in intensity between the two sides may lead to the error of regarding the resonance on the right side as dulness. The error is avoided by attention to the pitch, and the quality of the resonance. If dulness existed on the right side, the pitch of the sound should be higher on that side; on the other hand, if the difference in intensity be due to the greater amount of emphysema on the left side, the pitch is higher on that side, and the quality vesiculo-tympanitic. The attention of the student is particularly called to the foregoing points of distinction. Assuming that a vesiculo-

tympanitic resonance exists anteriorly on both sides, and that it is marked on the left as contrasted with the right side, how is the existence of this sign on the right side to be determined? The answer is, the resonance over the upper is to be compared with that over the lower lobe of the right lung. Percussing first over the upper lobe of the right lung, and second over the lower lobe of this lung, that is, posteriorly, below the scapula, or in the infra-axillary region, the vesiculo-tympanitic resonance over the upper lobe is rendered manifest. In a series of patients affected with emphysema, the uniformity of the results of percussion is very striking; anteriorly, over the left side, the resonance is vesiculo-tympanitic as compared with the resonance on the right side, and the resonance is shown to be vesiculo-tympanitic on the right side anteriorly, as compared with the resonance posteriorly below the scapula.

As regards the abnormal modifications of the respiratory murmur in emphysema, there is (1) either weakened respiratory murmur without notable change in pitch or quality, or suppression of the murmur. Diminished intensity of the murmur exists over the upper lobes on both sides, as compared with the murmur over the lower lobes; and in most cases the greater diminution or the suppression is on the left rather than on the right side. Exceptions to the latter statement may be caused by obstruction of the bronchial tubes on the right, and not on the left side, by an accumulation of mucus, and, in rare instances, by the fact that the emphysema is greater on the right side.

Occasionally there is almost suppression below, with preserved respiration above, of the emphysematous type, and this so continuous as not to be explained by obstruction of tubes. (2) Modifications in rhythm are not infrequent. These consist in a shortened (deferred) inspiratory, and a prolonged expiratory sound. In some instances an inspiratory sound is wanting, and an expiratory sound is alone heard. The prolonged expiratory sound in emphysema is always low in pitch and blowing or non-tubular in quality, in these respects differing from the prolonged expiration which denotes solidification of lung, the latter being high in pitch and tubular in quality. These essential points of difference I claim to have been the first to have distinctly stated.

The foregoing signs obtained by percussion and auscultation are those which are, in a positive sense, diagnostic of emphysema. Associated with these are certain important negative points, as follows: vocal resonance, vocal fremitus, and bronchial whisper are not notably altered. These negative points suffice to exclude other affections than emphysema.

Signs obtained by inspection are quite distinctive of this affection. Emphysema, existing in a marked degree, causes a characteristic deformity of the chest; the anterior surface is bulging, giving to the chest an abnormally rounded, bow-windowed, or barrel-shaped appearance, the lower part appearing to be contracted. This deformity occurs when the emphysema has been developed in early life. The movements of the chest in inspiration are characteristic.

In tranquil breathing there is but little movement of the upper and anterior regions, but in forced breathing the sternum and ribs move together as if they were one solid piece. The lower portion of the chest and the epigastrium are retracted in inspiration, or the retraction may be only apparent; the costal angle is diminished, the ribs and cartilages connected with the sternum being sometimes on a line; the soft parts above the clavicle and sternum are often notably depressed with inspiration. Owing to depression of the heart downward and inward, the cardiac impulses are seen and felt in the epigastrium. Percussion and vocal resonance show the superficial cardiac region to be diminished or lost, the upper lobe of the left lung covering this space. There may be more or less anterior curvature of the spine, and the lower portions of the scapulæ may project, so that sometimes the plane of these bones is almost horizontal. These striking appearances characterize cases in which emphysema exists in a marked degree, and especially when the affection dates from early life. They are less marked or wanting if the emphysema be moderate in degree, and it have taken place in middle-aged persons or those advanced in years.

In the variety of emphysema distinguished as senile, or senile atrophy of the lungs, in which there is coalescence of air-vesicles from destruction of the cell-walls without increased volume of the affected lobes, the diagnosis is to be based on the vesiculo-tympanitic resonance on percussion, weakened respiratory murmur, with, perhaps, the alterations in rhythm, sinking

of the soft parts above the clavicles, and the negative points, exclusive of deformity of the chest, which have been described.

Emphysema can hardly be confounded with any other affection than phthisis. The differentiation between these two affections is sufficiently easy if the diagnostic points, positive and negative, of the former, be appreciated. Phthisis occurring in a patient affected with emphysema makes a somewhat difficult problem in diagnosis; but, by strict attention to the associated history and symptoms, together with thorough examination of the sputum, errors will usually be avoided. Association of emphysema and pulmonary tuberculosis is not as uncommon as was formerly thought.

Owing to the frequency with which an asthmatic element enters into the clinical history of emphysema, the dry bronchial (sibilant and sonorous) rales are often present, even when paroxysms of asthma do not occur.

PLEURISY, ACUTE AND CHRONIC—EMPYEMA —HYDROTHORAX

In the first stage of acute pleurisy—that is, prior to the effusion of liquid—the physical conditions are, the presence of more or less recently exuded, soft lymph upon the pleural surfaces, which are now in contact, and restrained movements of respiration on the affected side in consequence of the pain which

they occasion. In the second stage, serous liquid accumulates within the pleural cavity, the quantity varying in different cases, sometimes, although rarely, filling the chest on the affected side. In proportion to the quantity of liquid, the space over which the pleural surfaces are in contact is restricted, the movements of these surfaces over each other are limited, and the lung is condensed. In the third stage the quantity of liquid decreases, the space over which the pleural surfaces are in contact increases, and the compressed lung is more or less expanded. The lymph upon the pleural surfaces becomes more dense and adherent. The surfaces may become agglutinated by the intervening lymph. Finally, in convalescence, permanent adhesions may result from the production or growth of areolar tissue. In subacute and chronic pleurisy there is the same series of physical conditions, the points of difference being, as a rule, a less amount of exudation, and a greater amount of effused liquid. The quantity of liquid in chronic pleurisy is often sufficient to compress the lung into a small solid mass situated at the upper and posterior part of the chest and to dilate the affected side. The heart is often removed from its normal situation. If the pleurisy be on the left side, the heart may be pushed laterally beyond the right margin of the sternum; if the pleurisy be on the right side, the heart is pushed laterally to the left of its normal situation.

In empyema the accumulation of pus is apt to be still greater than that of serous effusion in simple chronic pleurisy, causing, of course, greater dilatation of the chest, and more displacement of the heart.

In these varieties of pleurisy the affection, with rare exceptions, is unilateral.

In hydrothorax the conditions differ, (1) as regards the absence of the exudation of lymph; (2) the affection is usually bilateral, the effusion of liquid taking place in both pleural cavities; and, (3) although the quantity of liquid may be considerably greater on one side, and this is almost invariably the right side, the accumulation very rarely, if ever, is sufficient to cause much dilatation of the chest on that side, with complete condensation of the lung, and notable displacement of the heart.

The signs in the first stage of acute pleurisy are relative feebleness of the respiratory murmur on the affected side, from the restrained respiratory movements on that side, and a rubbing friction-sound. The friction sound cannot be heard if only the diaphragmatic or mediastinal pleura is inflamed. The former sign is not distinctive of pleurisy, being present when the respiratory movements on one side are restrained by pain in intercostal neuralgia and pleurodynia. A friction-sound is not always obtained. In the absence of this sound the physical diagnosis cannot be made with positiveness prior to the effusion of liquid.

When in doubt as to the site of origin of rales which may be friction-sounds or pulmonary crepitations, if the patient cough, the character of pulmonary rales is usually altered, and they may even disappear while pleuritic friction-sounds are unaffected. Also pressure of the stethoscope or hand may intensify the friction

rub but does not alter the pulmonary crepitation. The friction sound is usually, but not invariably, heard only in inspiration. Assuming that the general and local symptoms point to an acute inflammatory affection, the differential diagnosis relates to pleurisy and pneumonia. A pleural friction-sound may be present in the latter as well as the former of these two affections. The common sign of pneumonia, the crepitant rale, being wanting, the differentiation, in this stage, must rest on diagnostic points pertaining to the symptoms. The crepitant rale may occur at the inception of pleurisy, without coexisting pneumonia, the mechanism of production being the same as in pneumonia.

In the second stage of acute pleurisy the diagnostic signs are those which denote the presence of liquid within the pleural cavity. These signs are simple and distinctive. There is either dulness or flatness on percussion at the base of the chest, extending upward a distance proportionate to the quantity of liquid. If the trunk be in a vertical position—that is, the patient sitting or standing—the line of demarcation between the dulness or flatness and pulmonary resonance on the anterior aspect of the chest is curved, following somewhat more than the downward curvature of the ribs in the axilla, and approaching the area of cardiac dulness in the left, or the liver or cardiac dulness on the right side, in a downward slanting direction. Posteriorly, the line of dulness or flatness is found to be a curve, starting about two inches from the posterior median line, and reaching its highest point in a line drawn vertically through the tip of

the scapula, the curve then descending in the axilla, to reach the liver or cardiac dulness in front, according to the side and the amount of the effusion (Ellis', or Garland's line).

Having ascertained the line forming the upper boundary of dulness or flatness on the anterior aspect of the chest, the patient sitting or standing, if the position be changed to recumbency on the back, and the pulmonary resonance be found then to extend more or less below this line, this fact is demonstrative proof of the presence of liquid. Where there is free pleuritic exudate on one side, there is found with considerable uniformity a triangular area of dulness on the opposite or unaffected side. The base of this area is made by the line of the base of the lung, and extends two to three inches from the posterior median line; the vertical side is somewhat longer usually and is as high in the mid-line as the upper level of the fluid on the affected side. This is known as the paravertebral triangle of dulness. Proof in this way is obtained in a large majority of cases, the exceptional cases being those in which the pleural surfaces are united, either by agglutination or permanent adhesions, above the level of the liquid.[1] The resonance on percussion

[1] An additional means of determining the level of the fluid especially at the right base posteriorly where the presence of the liver may cause confusion on percussion is by tapping one coin held firmly against the upper chest in front with another coin, when the ear below the level of the fluid behind will detect a much better transmission of the sound thus produced than when the ear is above the level of the fluid. Flatness over fluid is usually more intense and the sense of resistance to the pleximeter finger greater than over consolidated lung.

over the lung above the level of the liquid is generally vesiculo-tympanitic—the intensity increased, the pitch raised, the vesicular and the tympanitic quality combined. Sometimes there is so little vesicular quality in this vesiculo-tympanitic resonance that it may seem to be purely tympanitic, and is suggestive of pneumothorax. Associated signs will always prevent this error of observation. As a rule, vocal resonance and fremitus are either notably lessened, or suppressed over the portion of the chest situated below the level of the liquid. There are occasional exceptions to this rule. The respiratory sound below the level of the liquid is suppressed. If any be heard, it is transmitted either from the lung above the liquid, or laterally, from the lung on the other side of the chest. Above the liquid the respiratory sound, as a rule, is weakened. If the amount of liquid be sufficient to produce much condensation of lung, the respiratory sound is broncho-vesicular. Sometimes, owing to the pleural surfaces above being adherent, a strip of lung at the level of the liquid is sufficiently condensed by compression to give a bronchial respiration. Under these circumstances, there will be either bronchophony or the modification of that sign known as egophony. If the lung be not sufficiently compressed for the production of these signs of solidification, the vocal resonance is simply more or less increased. The fremitus is usually increased above the liquid. Over the unaffected side the respiratory murmur is increased in intensity.

The foregoing signs are present when the pleural

cavity is partially filled; a quarter, a half, or two-thirds of the thoracic space being occupied by liquid. The signs present when the cavity is completely filled will be presently stated in connection with chronic pleurisy.

The signs which have been stated show not only the presence of liquid but its quantity. By means of these signs are readily ascertained the progressive increase or decrease in the quantity of liquid, and its disappearance. After the liquid has disappeared, often notable dulness on percussion remains for some time, showing the presence of lymph not yet absorbed. During the decrease of the liquid, and after its disappearance, a friction-murmur is often perceived. This murmur is now apt to be rough—a rasping, grating, or creaking sound. It may be loud enough to be heard by the patient, and by others at a distance from the chest. It continues sometimes for a considerable period.

The physical diagnosis in cases of chronic pleurisy, when the liquid occupies a portion only of the thoracic space, rests, of course, on precisely the same signs as in cases of acute pleurisy. If, however, the chest on the affected side be filled and dilated, certain of the signs which have been stated are wanting, and others are added. The affected side is everywhere flat on percussion. Flatness on percussion over the whole of one side, the affection being chronic, denotes, as a rule, with rare exceptions, either chronic simple pleurisy or empyema. Respiratory sound is wanting except at the summit over or near the compressed

lung, where it is bronchial. Some cases offer an important exception to this rule, namely, the bronchial respiration is diffused over the greater part, or even the whole, of the affected side. The student should bear in mind this fact, otherwise the diffusion of the bronchial respiration may lead to the suspicion that the flatness on percussion denotes solidification of lung and not the presence of liquid. Other signs, however, should always correct this error. Vocal resonance and fremitus are, with some exceptions, either suppressed or notably diminished over the whole of the affected side. Generally, even when the chest is not dilated, the intercostal depressions are lessened or abolished. If the walls of the chest be thinly covered with integument, the two sides present a marked contrast in this respect. This is seen especially at the middle and lower regions of the chest anteriorly and laterally. It is especially marked at the end of the inspiratory act. If the affected side be dilated, this is apparent on inspection, and may be determined accurately by semicircular or diametric mensuration, calipers being required for the latter. The respiratory movements on the affected side are diminished or annulled, and they are increased on the healthy side, the two sides affording a marked contrast in this regard. If the pleurisy be on the left side, the impulses of the heart are not infrequently felt on the right of the sternum. If the impulses cannot be felt, auscultation shows the maximum of the intensity of the heart sounds to be more or less removed to the right. If the pleurisy be on the right side

the impulses or sounds of the heart denote more or less displacement laterally to the left, and this altered position may be still further determined by percussion of the cardiac border adjacent to healthy lung. The intensity of the respiratory murmur on the unaffected side is notably increased.

In cases of empyema the same signs are present as in chronic pleurisy. The character of the liquid does not alter appreciably any of the signs which have been stated. Dilatation of the affected side of the chest is more apt to occur, and to be more marked than in simple pleurisy. The differential diagnosis between these two varieties of pleurisy is to be made with positiveness by the introduction of the needle of a hypodermic syringe having good suction force, previously cleaned and carbolized, and obtaining enough of the liquid to ascertain its character.

When the left pleural cavity is filled with pus, the movements of the heart sometimes give to the affected side of the chest an impulse perceived by the eye and touch; hence the term, pulsating empyema. This condition has been observed even when the empyema has been confined to the right pleural cavity. After a spontaneous perforation of the chest, followed by a circumscribed purulent collection beneath the integument, communicating with the pus within the pleural cavity, the tumor thus formed sometimes has a strong pulsation which is synchronous with the ventricular systole, and may give rise to the suspicion of aneurism.

In cases of hydrothorax, the signs denote partial filling of the chest on both sides. The affection is

bilateral. Generally the quantity of liquid in the two sides is not equal, and there is often a notable disparity in this respect. Friction-sounds are never present. Variation of the level of the liquid with change of the position of the patient from the vertical to the horizontal is nearly always determinable. Hydrothorax, meaning by this term a purely dropsical affection, is to be differentiated from double pleurisy with effusion. The history and symptoms, taken in connection with the signs, suffice for this discrimination.

Exceptional Physical Signs in Pleurisy.[1]—"The vocal fremitus may not be lost below the level of the fluid.

"Above the level of the fluid, over the compressed lung, there may be cavernous breathing and gurgling rales.

"A sub-crepitant rale may be heard below the level of the fluid, the level being demonstrated by the aspirator.

"Sacculated effusions give irregular physical signs which vary with the position of the fluid. The effusions are most easily made out if they are in contact with the wall of the chest.

"Most of the sacculated pleurisies I have seen have been situated about the root of the lung, gave the maximum flatness at some point between the scapula and the vertebral column, and were best aspirated at the point of maximum flatness. In some of these cases there was flatness and absence of breathing over the fluid; in some, flatness and bronchial voice

[1] Delafield: Lectures on the Practice of Medicine, 1903.

and breathing; in some there was pulmonary resonance with bronchial voice and breathing over the lower part of the chest where there was no fluid."

PNEUMOTHORAX—PNEUMO-HYDROTHORAX —PNEUMO-PYOTHORAX

In the extremely rare cases of pneumothorax, that is, as distinguished from pneumo-hydrothorax and pneumo-pyothorax, the physical conditions are: the presence of air partially or completely occupying the thoracic space, and condensation of lung in proportion to the space occupied by air.

The diagnostic signs are, a purely tympanitic resonance over a portion or the whole of the affected side of the chest: suppression of the vesicular murmur over a space corresponding to that in which tympanitic resonance is obtained, with notable diminution or suppression of vocal resonance and fremitus. Over the compressed lung, if the condensation amount to complete or considerable solidification, there will be bronchial respiration and bronchophony; if the solidification be neither complete nor considerable, there will be broncho-vesicular respiration with increased vocal resonance and fremitus. The accumulation of air may be sufficient to dilate the affected side, and to restrain or annul the respiratory movements on this side. The appearances on inspection are then precisely the same as in the cases of chronic pleurisy and empyema, in which the affected side is

dilated from the presence of liquid. Pneumothorax is, however, at once differentiated by the tympanitic resonance on percussion. If one side of the chest be more or less dilated, and the resonance over the side be purely tympanitic, the thoracic space must be filled, not with liquid but with air. The intensity of the respiratory murmur on the healthy side is increased. The heart is displaced toward the unaffected side of the chest.

In the great majority of cases in which the pleural cavity contains air, there is also present more or less liquid, which may be serous or purulent. The affection is then known as pneumo-hydrothorax if the liquid be serous, and pneumo-pyothorax if it be purulent. The physical conditions are the same as in pneumothorax, with the addition of the presence of liquid. The relative proportions of liquid and air in different cases are variable, and, also, in the same case at different periods.

The physical diagnosis of pneumo-hydrothorax and of pneumo-pyothorax, as distinguished from pneumothorax, embraces the signs of liquid, in addition to those of air, within the pleural cavity. If the quantity of liquid be large or considerable, percussion at the base of the chest gives flatness, extending upward more or less, and tympanitic resonance above, the patient either sitting or standing. A change from the vertical to the horizontal position invariably causes variation of the upper limit of the flatness, inasmuch as the liquid and air change their relative situations without an exception. The quan-

tity of liquid is determined approximatively, by ascertaining the space over which the flatness on percussion extends. The line which divides the flatness and the tympanitic resonance does not accurately denote the level of the liquid, because tympanitic resonance is transmitted a certain distance below this level, hence it is always to be assumed that the level of the liquid is somewhat higher than the upper boundary of the flatness.

In either pneumothorax, pneumo-hydrothorax, or pneumo-pyothorax a group of auscultatory signs is often found which are highly diagnostic, indeed almost pathognomonic. These signs are amphoric respiration, amphoric voice or echo, and metallic tinkling. The amphoric and the tinkling sounds may be present, either without the other, but they are not infrequently associated. Both signs are absent in some cases and they are not present in the same case at all times; their absence, therefore, by no means excludes the affections, and they are not essential to the diagnosis. When present they denote either air, or air and liquid, in the pleural cavity with perforation of lung, or a large phthisical cavity. Their occurrence in the latter is comparatively rare, and whenever they are associated with other signs already stated, their diagnostic import is demonstrative.

Pneumo-hydrothorax or pneumo-pyothorax may almost invariably be diagnosticated instantly by the presence of a succussion sound. Whenever distinct splashing is produced by succussion and referable to the chest, that is, not produced within the stomach,

it is demonstrative of the presence of air and liquid within the pleural cavity.

Whenever there is a large free air space within the thorax, such as occurs in the conditions described above, a distinctive quality is given to the sound heard through the affected side, when a coin is tapped sharply against another held firmly in contact with the chest-wall. The sound produced, instead of being distant and muffled as through a normal lung, is clear, intense, ringing, and can be likened to the sound a small pebble makes when dropped into a deep well.

ACUTE LOBAR PNEUMONIA

In the first stage of this disease there is an abnormal accumulation of blood within the vessels of the affected lobe (active congestion or hyperemia), with some exudation within the air-vesicles and bronchioles. Generally there is some exuded lymph upon the pleural surface, this being due to circumscribed dry pleurisy. In most cases there is also circumscribed bronchitis, which is limited to the tubes within the affected lobe. In the second stage there is solidification due to the increase of exudation within the air-vesicles. The solidification, at first limited, extends either rapidly or slowly, as a rule, over the whole lobe. Exceptionally more or less liquid effusion into the pleural cavity takes place (pleuro-pneumonia), the pleurisy then extending beyond the limits of the affected lobe. In this stage the pneumonia may involve

either another lobe of the lung primarily affected, or a lobe of the opposite lung, and sometimes the disease, by successive invasions, extends over the whole of one lung, together with a lobe of the opposite lung. The pneumonia, in these secondary invasions, is usually accompanied by pleurisy and bronchitis. In the stage of resolution the solidification of the affected lobe or lobes decreases, sometimes rapidly and sometimes slowly, until the normal condition is restored. If resolution does not take place, and the disease pass into the stage of purulent infiltration, the air-vesicles and bronchial tubes contain a puruloid liquid in greater or less quantity. Exceptionally pus is collected in a cavity, or in cavities, constituting pulmonary abscess.

The physical diagnosis of acute lobar pneumonia in the first stage must be based on the presence of the crepitant rale, with moderate or slight dulness on percussion, and diminished vesicular respiratory murmur over the affected lobe. There is sometimes in this stage a pleuritic rubbing sound over the affected lobe. The crepitant rale is not always present, and hence the affection cannot be excluded by the absence of this sign. When present, taken in connection with the symptoms, this sign is of great diagnostic value. It is important not to mistake for this sign fine bubbling, or the subcrepitant rale. When the crepitant rale is wanting, a positive physical diagnosis must be deferred until more or less of the affected lobe becomes solidified, that is, when the disease passes into the second stage.

The diagnosis in the second stage is to be based on the signs of solidification furnished by auscultation and percussion. The auscultatory signs are the broncho-vesicular, followed by the bronchial respiration; increased vocal resonance, followed by bronchophony, and increased bronchial whisper, followed by whispering bronchophony. The signs of solidification are manifested at first within a circumscribed space, situated over either the upper, the lower, or the middle portion of the affected lobe, and either rapidly or slowly the signs extend, in most cases over the entire lobe. The crepitant rale, if it have been present in the first, generally disappears in the second stage. Sometimes, however, it is not entirely lost in this stage. The broncho-vesicular respiration, increased vocal resonance, and increased bronchial whisper are present when the solidification is slight or moderate; the bronchial respiration, bronchophony, and bronchophonic whisper take their place when the solidification becomes considerable or complete. The latter signs, as a rule, speedily follow, inasmuch as the solidification in most cases quickly becomes complete or considerable. The foregoing three signs, denoting considerable or complete solidification, are usually present. Bronchial respiration, however, is sometimes present without bronchophony, and *vice versa.* Either, present alone, suffices to show the existence and the extent of the solidification. Moist bronchial or bubbling rales are sometimes, but rarely, heard over the affected lobe.

There is notable dulness on percussion in the second

stage. The dulness may approximate and even amount to flatness. If a single lobe be affected, the dulness or flatness extends over a space corresponding to that occupied by the lobe or the portion of it which is solidified. In the anterolateral aspects of the chest, the dividing line between the solidified and the healthy lobe is readily ascertained by percussion, and this line is coincident with the interlobar fissure.[1] It sometimes happens that the upper and the lower lobe of the right lung are affected, the middle lobe not becoming involved. The space corresponding to the middle lobe may then form an island of resonance surrounded by notable dulness on percussion.

Whenever one lobe of a lung is affected, the resonance over the unaffected part of the same lung is abnormally increased, the pitch is raised, and the quality is vesiculo-tympanitic; vesiculo-tympanitic resonance, in other words, is produced. This renders more marked the contrast between dulness over the solidified, and resonance over the healthy, lobe.

Over a portion of an upper lobe in the second stage, instead of notable dulness or flatness, there may be marked tympanitic resonance. This resonance proceeds from air within the trachea and the bronchi exterior to the lungs, the lung substance being completely solidified; it is chiefly or especially marked over the site of these air-tubes. In some cases the

[1] With reference to the localization of pneumonia in the upper or lower lobes the situations of the interlobar fissures on the anterior, posterior, and lateral aspects of the chest are to be kept in mind (*vide* Figs. 1, 2, 3, 4, pages 42 to 45).

tympanitic resonance has either the cracked-metal or the amphoric intonation. These signs, *per se*, might suggest either pneumothorax or phthisical cavities; the associated respiratory and vocal signs, however, show only solidification of lung. In cases of pneumonia affecting the left lung, a tympanitic resonnance is not infrequently propagated from the stomach more or less upward over the affected side of the chest. This may be readily traced to the stomach. On the right side, a tympanitic resonance is sometimes propagated a certain distance upward from the transverse colon.

The commencement of the stage of resolution is denoted by a broncho-vesicular respiration. The first change observed is the presence of a little vesicular quality in the inspiratory sound. When this is observed, the respiration is no longer bronchial, but has become broncho-vesicular, although the pitch is still high, and the expiration is prolonged, high, tubular. This slight change shows that air begins to enter the pulmonary vesicles. As resolution goes on, more and more of the vesicular takes the place of the tubular quality in the inspiratory sound, and the pitch is lowered in proportion; the expiratory sound becomes proportionately less and less prolonged, its pitch lowered, its quality less tubular, until, at length, the normal characters of the respiratory murmur are regained. Resolution is then complete.

While the broncho-vesicular respiration is undergoing the modifications just stated, the vocal sounds have corresponding changes. Bronchophony per-

sists for some time after the respiration has become broncho-vesicular, and then disappears, increased vocal resonance generally taking its place and persisting until resolution is completed. The bronchial whisper loses its bronchophonic characters, and is simply increased until its normal characters are regained. While the solidification is complete, the vocal fremitus may, or may not, be increased. It is sometimes diminished. When, however, resolution has so far progressed that bronchophony is lost, the fremitus is usually greater than in health, and so continues, but progressively lessening until the solidification entirely disappears.

During the progress of resolution, the dulness on percussion diminishes in proportion as air enters the air-vesicles. If tympanitic resonance have been present over the upper lobe, this gives place to a vesicular resonance. Some dulness, however, remains after the completion of resolution, and persists until the exuded lymph on the pleural surface is absorbed. The amount of dulness remaining when the respiratory and vocal signs denote resolution, is proportionate to the quantity of exudation incident to the associated pleurisy.

In this stage the crepitant rale not infrequently returns, if it have entirely disappeared during the second stage, and if it have persisted, it is more marked and diffused. It is now known as the returning crepitant rale. More frequently the rale in this stage is a fine bubbling or the so-called sub-crepitant. Both rales are not infrequently associated, and, from the

distinctive characters of each, they are readily distinguished. Moist rales, more or less fine or coarse, are not infrequent. The pitch of these rales remains more or less high until the solidifying exudation is completely absorbed.

If the affection pass into the stage of purulent infiltration, the respiratory sounds are feeble or suppressed, having, if present, more or less of the bronchial characters. Bubbling bronchial rales, coarse and fine, are abundant. Weak bronchophony may persist, or the vocal resonance may be diminished. Fremitus may, or may not, be increased. Notable dulness or flatness on percussion remains.

If the pneumonia result in pulmonic abscess, there will be notable dulness or flatness on percussion within a circumscribed space, together with absence of respiratory murmur, and diminished or suppressed vocal resonance. These signs warrant a probable diagnosis which is corroborated by the sudden expectoration of pus in a considerable quantity. The signs just stated may then be followed by those denoting a cavity—namely, cavernous respiration and whisper, with intense vocal resonance.

CIRCUMSCRIBED PNEUMONIA—EMBOLIC PNEUMONIA—HEMORRHAGIC INFARCTUS OR PULMONARY APOPLEXY

The form of pneumonia known as lobular pneumonia, occurring in children, has been considered

(*vide* Bronchitis seated in small-sized tubes). Whenever circumscribed, as a rule, pneumonia is secondary to some other pulmonary affection. Circumscribed pneumonia, giving rise to an intra-vesicular exudation, which may disappear readily by resolution or absorption, is not very infrequent in cases of phthisis. The signs are those which represent solidification of lung within an area more or less circumscribed; but the differentiation, from the solidification proper to phthisis, can only be made with positiveness, after the signs have shown that the solidification has notably diminished, or disappeared.

In embolic pneumonia there may be dulness on percussion, with feeble bronchial or broncho-vesicular respiration, or suppression of respiratory sound, weak bronchophony or increase of vocal resonance, within a circumscribed space, or within spaces, generally on the posterior aspect of the chest, and oftenest on the right side. These signs, taken in connection with the symptoms and pathological conditions which are consistent with the supposition of emboli received into the right side of the heart, namely, when the pulmonary symptoms follow puerperal disease, ulcers, wounds, injuries, or venous thrombosis, render the diagnosis quite positive. If, however, the pulmonary affection consist of small disseminated nodules, the foregoing signs will not be present. The diagnosis then must be based on the history and symptoms, taken in connection with the exclusion of other pulmonary affections by the absence of signs, which should be present if they existed. Bubbling rales, the pitch

more or less raised, at different situations may indicate the probable sites of the nodules. There may be pleuritic friction-sounds. The signs may show, as a complication, pleurisy with effusion.

Extravasation of blood (pneumorrhagia), if it be in small spaces, gives rise to no definite physical signs. If, however, extravasation extend over a considerable space, there will be dulness on percussion, with feeble or suppressed respiratory sound within an area corresponding to the extent of the extravasation. Within, and near this area, there will be likely to be moist bronchial rales more or less fine or coarse.

PULMONARY GANGRENE

In diffused pulmonary gangrene the physical signs are those of solidification extending over the greater part or the whole of a lobe. The diagnosis, however, can only be made when, in connection with these signs, there are present the characteristic fetor of the breath and expectoration.

In circumscribed gangrene there is dulness or flatness on percussion within an area corresponding to the extent of the affection, with either suppression of respiratory sound or bronchial respiration, and the vocal signs of solidification. Within and near this space moist bronchial rales, more or less raised in pitch, are likely to be heard. The situation is usually on the posterior aspect of the chest. These signs do not suffice for a positive diagnosis without

the characteristic breath and expectoration. Cavernous signs may appear after the gangrenous portion of lung has sloughed away and been expectorated.

PULMONARY EDEMA

The physical condition expressed by the term pulmonary edema is the presence of effused serum within the air-vesicles. With this condition is associated more or less pulmonary congestion.

In cases of pulmonary edema developed rapidly and largely in connection with renal disease, with obstruction at the mitral orifice of the heart, or with both these affections combined, giving rise to great dyspnea, and liable to end speedily in death, the following are the diagnostic signs: Dulness on percussion on both sides of the chest, especially over the lower lobes, fine bubbling or so-called subcrepitant rales diffused over the chest on both sides, together with coarser bubbling sounds, and the murmur of respiration notably weak or suppressed over the lower lobes. Inasmuch as the lungs are not solidified the rales are low in pitch. The vocal signs of solidification are, of course, wanting. Occasionally the crepitant rale is mingled with the fine bubbling sounds.

This form of the affection is to be differentiated from hydrothorax with large effusion, and from so-called capillary bronchitis. Hydrothorax is always associated with more or less anasarca, or general dropsy, whereas, pulmonary edema, even when depen-

dent on renal disease, may occur without dropsical effusion elsewhere. Moreover, the presence of liquid within the pleural cavities, and its amount, may always be determined demonstratively in cases of hydrothorax (*vide* Pleurisy with effusion and Hydrothorax). Capillary bronchitis occurs chiefly in children. The so-called subcrepitant rale on both sides of the chest is the diagnostic sign of this affection, but it is not accompanied by dulness on percussion, except in so far as the bronchitis may be associated with lobular pneumonia or collapse of pulmonary lobules. The rapid development of the edema and its pathological connections are diagnostic points to be taken into account.

Pneumonia is excluded by the fact that the affection is at the beginning bilateral, and by the absence of the signs of solidification of lung.

Pulmonary edema less in degree and diffusion, has, of course, the same signs, not as marked and not as extensive—namely, dulness on percussion and fine bubbling sounds or the so-called subcrepitant rales. In this form the affection is bilateral, and seated especially in the posterior and inferior portions of the lungs. Moreover, this form has the same pathological connections, namely, with disease of the kidneys, and mitral lesions of the heart. The low pitch of the bronchial rales, and the absence of the respiratory and vocal signs of solidification, together with the fact of the affection being bilateral, and the coexistence of disease of the heart or kidneys, constitute the basis of a positive diagnosis.

Hypostatic congestion of the lungs may occasion a certain amount of pulmonary edema. The physical diagnosis is to be based on bilateral dulness on the posterior aspect of the chest, with low-pitched, fine bubbling sounds, or the so-called subcrepitant rales on both sides, these signs occurring under circumstances which lead to the supposition of this form of congestion.

NEOPLASMS OF LUNG—TUMORS WITHIN THE CHEST

Neoplastic growths in the lungs are usually in the form of nodules varying in size from that of a pea to a hen's egg, disseminated throughout one lung or both lungs, in greater or less numbers. These disseminated nodules, if of small size, have no well-marked, definite diagnostic signs. If limited to a lung, or if greater in number in one lung, they may occasion an appreciable dulness on percussion. They may also occasion feebleness of the respiratory murmur, and, owing to coexisting circumscribed bronchitis, moist bronchial rales may be heard at different points. These signs warrant a diagnosis when, as is usually the case, cancer is known to have existed elsewhere. With reference to diagnosis, it is to be borne in mind that, when cancer of the lung is secondary, both lungs are affected, and, when it is primary, the affection is generally unilateral.

If there be nodules of considerable size, there will be well-marked dulness on percussion in different

situations, and the signs of solidification may be present, namely, either bronchial or broncho-vesicular respiration, either increased vocal resonance or bronchophony, and increased vocal fremitus.

In some cases of unilateral carcinoma, the greater part, or the whole, of a lung may be infiltrated with the morbid growth, increasing its volume and giving rise to enlargement of the affected side, diminished respiratory movements or immobility, flatness on percussion, with diminished or suppressed respiratory murmur, vocal resonance, and fremitus. If, as is usual, there be also more or less pleuritic effusion, the intercostal spaces may be pushed out to a level with the ribs. Here are the signs which denote chronic pleurisy with large effusion, and the differential diagnosis cannot be made with positiveness until the fluid within the chest be withdrawn, and it be found that, irrespective of the bulging of the intercostal spaces, the physical signs remain. Exploration with a small trocar, or hollow needle, will settle the diagnosis when there is no pleuritic effusion, and this procedure is unobjectionable.

In other cases the neoplastic growth induces atrophy of the lung, diminishing its volume, and causing notable contraction of the affected side. The appearances on inspection are those which denote contraction after chronic pleurisy, and they may be present also in cases of fibroid phthisis or cirrhosis of lung. The differential diagnosis must be based chiefly on diagnostic points relating to the history and symptoms.

Tumors within the chest, generally having their points of departure in the mediastinum, displace the lung in proportion to their size. They may cause considerable displacement of the heart, and produce more or less enlargement of the chest with diminished respiratory movements. Enlargement of the subcutaneous veins, indicative of venous obstruction, is often to be observed. Over the site of the tumor, there will be either dulness or flatness on percussion. Generally respiratory sound is wanting, vocal resonance and fremitus being either diminished or suppressed. In the neighborhood of the primary bronchi and over lung compressed by the tumor, there may be bronchial respiration, with bronchophony and increased fremitus. If the chest be enlarged, its enlargement is not likely to be as uniform as when it is dilated with liquid; this is a diagnostic point. The tumor, or the tumors, may not be confined to one side of the chest. It is to be borne in mind that pleurisy with effusion may exist as a complication, and this may serve to obscure the diagnosis.

The physical diagnosis involves differentiation from pericarditis with effusion and aneurisms. These affections are to be excluded by the absence of their diagnostic signs.

ACUTE MILIARY TUBERCULOSIS

The physical condition in this affection is the presence of a large number of the small bodies known as tubercles or miliary granulations, disseminated

throughout both lungs. Bronchitis is an associated affection.

If the tubercles be about equally distributed in the two lungs, there is no abnormal disparity of the resonance on percussion between the two sides of the chest. A comparison, also, of the two sides may afford no disparity as regards the respiratory murmur, vocal resonance, and fremitus. Moist rales, due to the associated bronchitis, may be present in different situations. A physical diagnosis, under these circumstances, cannot be made with positiveness. Physical exploration, however, is important in order to exclude other affections; and the negative result, taken in connection with the symptoms—hyperpyrexia, rapid pulse, accelerated breathing, etc.—renders the diagnosis extremely probable. The differential diagnosis involves discrimination from capillary bronchitis, and an essential fever with a bronchial complication. The affection has been repeatedly mistaken for typhoid fever.

The tubercles may be more abundantly distributed in one lung. A disparity in the resonance on percussion may then be apparent, and, perhaps, an abnormal increase of vocal resonance and fremitus. These signs, taken in connection with the symptoms, establish the physical diagnosis.

PHTHISIS

With reference to physical diagnosis, cases of phthisis may be conveniently distributed into three groups, as

follows: (1) Cases in which the pulmonary affection is small, or cases of incipient phthisis; (2) cases in which the affection is moderate or considerable; and (3) cases in which the affection has progressed to the formation of cavities, or cases of advanced phthisis.[1]

In cases of incipient phthisis the essential physical condition is the presence of small solidified masses, or nodules, the intervening vesicular structure not being affected. These nodules vary from the size of a pea to a filbert. In the vast majority of cases they are situated at or near the apex of either the right or the left lung. Generally, circumscribed capillary bronchitis coexists in proximity to the nodules. An intercurrent circumscribed pneumonia sometimes occurs, giving rise to transient solidification within a limited area. Dry circumscribed pleurisy situated over the affected portion of lung, generally occurs from time to time.

In the cases of a moderate or a considerable pulmonary affection, the difference, as compared with the preceding group of cases, consists in the presence of nodules of large size, or solidification from the phthisical deposit extending over a space, or spaces, sufficient in size to give rise to well-marked physical signs. The solidification in these cases may be extended

[1] At present the so-called Turban, and National Association, classifications for clinical stages or groups of pulmonary tuberculosis are so superior to any previously used, and are so universally followed at the present time, that the reader is urged to make use of them to the exclusion of less exact definitions (see p. 350).—Ed.

by the development of circumscribed interstitial pneumonia. The circumscribed bronchitis is greater, as a rule, in degree and extent; attacks of dry pleurisy may continue to occur, and the pleural surface becomes adherent. In these cases, generally, the affection, existing primarily in one lung, now exists in both lungs. The volume of the lung first affected, at the summit, is more or less diminished. Enlargement of the bronchial glands is usual, and these may be so situated as to press upon and diminish the calibre of one of the primary bronchi. In some cases, portions of lung in the neighborhood of solidified masses or nodules are emphysematous (vicarious emphysema).

Cases of advanced phthisis are characterized by the presence of a cavity, or, commonly, of cavities, varying in number, size, rigidity or flaccidity of the walls, freedom of communication with bronchial tubes, and the nearness of their situation to the superficies of the lung. In cases of progressive phthisis, in addition to cavities, there is more or less solidification from phthisical exudation and interstitial pneumonia. The volume of the lung at the summit is often notably diminished. The pleural surfaces are firmly adherent. If, however, the disease have been retrogressive or non-progressive, there may be little or no solidification of lung, the cavity or cavities forming the only lesion. In cases of advanced phthisis, with very rare exceptions, both lungs are affected, and cavities often exist on both sides.

The physical diagnosis in cases of incipient phthisis embraces what may be called direct and accessory

signs. The accessory signs are those which represent incidental affections—namely, circumscribed bronchitis, pleurisy, and pneumonia. The direct signs are those representing the essential condition, namely, the solidified masses or nodules.

An important direct sign is dulness on percussion. Slight dulness on percussion at the summit of the chest, in front or behind, is a highly important sign, taken in connection with symptoms, of incipient phthisis. In determining that a relative dulness is abnormal, the student must bear in mind, in the first place, the normal disparity between the two sides. The right side at the summit is relatively somewhat dull on percussion in healthy persons. Due allowance is to be made for this normal disparity. In the second place, it is to be borne in mind that any deformity affecting the symmetry of the chest will affect the relative resonance on the two sides; and that a deviation from symmetry attributable to the position of the patient will occasion a disparity on percussion. In the third place, the rules for the practice of percussion must be kept in mind, in order to avoid producing apparently an abnormal disparity by the non-observance of these rules (*vide* p. 69 *et seq.*). Normal resonance on percussion on the two sides is a strong point for the exclusion of incipient phthisis.

The direct respiratory signs in incipient phthisis are the broncho-vesicular respiration and weakened vesicular murmur. To these is to be added a localized interrupted or wavy inspiratory murmur, as an occasional sign. Of course, familiarity with the

characters of the broncho-vesicular respiration is indispensable—the combination of the vesicular and the tubular quality in the inspiratory sound, with the pitch raised in proportion to the amount of tubularity, and the expiratory sound more or less prolonged, high, and tubular. Not infrequently the only appreciable morbid modification is diminished intensity of the murmur. When this sign is present, it is probable that the lack of intensity is the reason for the absence of the characters of the broncho-vesicular modifications, that is, the latter sign would have been present were the respiratory sounds more intense.

The direct vocal signs in incipient phthisis are increased vocal resonance, increased bronchial whisper, and increased fremitus. The other direct signs may be present without an appreciable morbid increase of the vocal resonance or fremitus. The increased whisper may also be wanting, but more rarely than the two other vocal signs.

In deciding on the presence or absence of each and all of these direct signs, it is essential to know and to judge correctly of the disparity between the two sides of the chest at the summit in health. Normally the resonance or percussion at the summit on the right side is slightly dull as compared with the left side; the inspiratory sound on this side has some tubularity in quality, and is somewhat raised in pitch; the expiratory sound may be more or less prolonged, high, and tubular; the vocal resonance on the right side is always greater, the same being

true of fremitus; the bronchial whisper is louder on the right side, and the intensity of the respiratory murmur is a little less on this side. Whenever it is a question as to a small phthisical affection at or near the apex of the right lung, it is a matter of experience and judgment to decide if the disparity in respect of these points be greater than normal, and it is not always easy to come at once to a decision. From the want of a proper appreciation of the several points of disparity in health, it is not uncommon for an erroneous diagnosis of phthisis to be based thereon. Appreciating the normal points of disparity, it is obviously easier to determine that the several direct signs of incipient phthisis are present at the left than at the right summit; relative dulness on percussion, broncho-vesicular or weakened respiration, increased vocal resonance, whisper, and fremitus, at the left summit are, of course, always abnormal.

Corroborative evidence of incipient phthisis may be obtained by the presence of accessory signs. These are: (1) Fine bubbling or the so-called subcrepitant rale at the summit on one side. This sign denotes a circumscribed capillary bronchitis, and this, at the summit on one side, is usually associated with phthisis. (2) A crepitant rale at the summit on one side denotes a circumscribed pneumonia which is usually secondary to phthisis. (3) A pleuritic friction-sound limited to the summit on one side is evidence of a dry circumscribed pleurisy which occurs often in the early stage of phthisis. (4) Indeterminate rales, crumpling and crackling, are significant of phthisis

if limited to the summit on one side. These rales, it is to be recollected, are sometimes found in healthy persons on forced breathing, especially if the binaural stethoscope be employed. If they be normal they are found on both sides. The accessory signs are not sufficient for a postive diagnosis if they exist alone; but they are to be considered as corroborating the evidence derived from the direct signs, together with the symptoms and history. It is of service often in bringing out the rales to cause the patient to cough.

As regards differential diagnosis, the affections with which incipient phthisis is likely to be confounded are chronic bronchitis and moderate emphysema. With respect to the first of these affections—namely, bronchitis—the differentiation must depend on the presence or the absence of positive signs of phthisis; in other words, phthisis is either diagnosticated or excluded. The physical signs in cases of moderate emphysema sometimes lead to the error of supposing this affection to be phthisis. Owing to the relatively greater intensity of the resonance on percussion at the left summit, dulness is thought to exist at the right summit, and a prolonged expiration, with the normally greater vocal resonance at the right summit, are regarded as signs of phthisis. This error may be avoided by a careful study of the signs of emphysema and the normal disparity in respiration, vocal resonance, and fremitus, existing between the two sides of the chest.

The physical diagnosis of a phthisical affection

which is considerable or moderate in amount, is, in most cases, an easy problem. Inspection often furnishes marked signs. The upper anterior portion of the chest on one side is depressed or flattened, and the superior costal movements of respiration are diminished, the chest elsewhere being symmetrical in both size and motions. There is more or less marked dulness on percussion at the upper part of the chest on the affected side. Sometimes the diminished resonance is tympanitic in quality (tympanitic dulness) without the existence of cavities, the resonance being transmitted from the primary and secondary bronchial tubes. The respiration is either bronchial or broncho-vesicular approximating more or less to the bronchial. Occasionally, however, the respiratory sounds are too feeble for their characters to be appreciated. There is either bronchophony, or the vocal resonance is notably increased without the bronchophonic characters. The whisper is either distinctly bronchophonic or it is notably increased in intensity, high in pitch, and tubular in quality. Vocal fremitus is often increased. Moist bronchial rales, coarse or fine, are generally present. With these diagnostic signs on one side, the signs of a smaller amount of disease are generally present on the other side.

In some cases of a moderate phthisical affection, the judgment may be confused by the resonance on percussion being increased or vesiculo-tympanitic on the affected side. This sign denotes the coexistence of emphysematous lobules (vicarious emphysema) developed in the progress of phthisis. The

diagnosis of the latter affection is then to be based on the signs obtained by auscultation.

In advanced phthisis the physical diagnosis of the disease is easy. The signs distinctive of this stage of the disease are those which denote pulmonary cavities — namely, tympanitic resonance on percussion within a circumscribed space; cracked metal or amphoric resonance; cavernous respiration; cavernous whisper and sometimes pectoriloquy; amphoric respiration and voice, and gurgling (*vide* Chapter V for description of these signs).

The cavernous signs are generally associated with the signs of solidification. In some cases, however, in which the disease has been non-progressive and retrogressive, the cavernous signs are present without the signs which denote solidification of lung.

FIBROID PHTHISIS—INTERSTITIAL PNEUMONIA, OR CIRRHOSIS OF LUNG

In this affection the physical conditions are, solidification from hyperplasia of the interstitial pulmonary tissue, dilatation of bronchial tubes (bronchiectasis), and diminished volume of the lung affected. The affection, as a rule, is either limited to or especially marked on one side. The whole of a lung, or only a portion of it, may be affected. Bronchitis always coexists.

There is notable dulness on percussion, the dim-

inished resonance being sometimes tympanitic. The degree of resonance may vary at different examinations, owing to differences in the amount of morbid products within the bronchial tubes. The respiration is bronchial, or broncho-vesicular. At times, from obstruction of bronchial tubes, it may be suppressed. Bronchophony and increased vocal resonance are the vocal signs, together with the corresponding whispering signs. The side of the chest which is chiefly or exclusively affected becomes contracted either entirely or in part, resembling in this respect the appearances after chronic pleurisy.

With these signs the affection is to be differentiated from the ordinary form of phthisis, by reference to points pertaining to the symptoms and history.

DIAPHRAGMATIC HERNIA

The presence of more or less of the abdominal viscera within the thoracic cavity in consequence of a congenital deficiency of a portion of the diaphragm, or perforation from accidents, or enlargement of the natural openings, gives rise to certain anomalous signs—namely, a tympanitic resonance, variable at different times owing to differences as regards the quantity of gas within the viscera; absence of the respiratory murmur from the base of the chest upward, the height proportional to the space occupied by the abdominal organs, and the intestinal sounds emanating from within the chest, not conducted from below.

This extremely rare affection can only be confounded with pneumothorax or a pleural effusion, when the stomach is full of food.

The use of the x-ray is invaluable in this condition, and gives positive evidence as to the physical relations of the diaphragm, and the abdominal, and thoracic viscera.

CHAPTER VII

THE PHYSICAL CONDITIONS OF THE HEART IN HEALTH AND DISEASE. THE HEART-SOUNDS AND CARDIAC MURMURS

Physical conditions of the heart in health: Boundaries of the precordia—Normal situation of the apex-beat—Boundaries of the deep and of the superficial cardiac space—Relations of the aorta and the pulmonary artery to the walls of the chest—The heart-sounds—Characters distinguishing the first and the second sound—Mechanism of the production of the heart-sounds—Auscultation of the pulmonic and the aortic second sound separately—Movements of the auricles and ventricles in relation to each other—Physical conditions of the heart in disease: Enlargement of the heart—Hypertrophy and dilatation—Abnormal impulses of the heart, and modifications of the apex-beat—Valvular lesions—Roughness of the pericardial surfaces—Liquid within the pericardial sac—Abnormal modifications of the heart sounds—Reduplication of heart-sounds—The pulse—Frequency of pulse—Regularity of pulse—Size of pulse—Rapidity of pulse—Tension of pulse—Character of arterial wall—Capillary pulsation—Pulsation of the cervical veins—Cardiac murmurs—Normal and abnormal blood currents within the heart, and their relations with the heart-sounds—Mitral direct murmur—Mitral regurgitant murmur—Mitral systolic non-regurgitant, or intra-ventricular murmur—Aortic direct murmur—Aortic regurgitant murmur—Aortic diastolic non-regurgitant murmur—Coexisting endocardial murmurs—Tricuspid direct murmur—Tricuspid regurgitant murmur—Pulmonic direct murmur—Pulmonic regurgitant murmur—Facts of practical importance in relation to endocardial murmurs—Pericardial or friction murmur.

Before entering upon the study of the physical diagnosis of the diseases of the heart, the student

must be familiar with its anatomy and physiology. For a description of the structure and functions of this organ, he is referred to anatomical and physiological treatises. The plan of this work embraces the anatomical relations of the heart and the space which it occupies within the chest, as physical conditions of health determinable by normal signs, together with the heart-sounds. Having briefly stated these conditions of health, the morbid physical conditions which may be ascertained by percussion, auscultation, and other methods of physical exploration, will be considered. The latter heading will include an account of the cardiac murmurs.

THE PHYSICAL CONDITIONS OF THE HEART IN HEALTH

The Precordia.—The Superficial and the Deep Cardiac Space.—The area on the surface of the chest corresponding to the space which the heart occupies within the chest, is the precordial region, or the precordia. The upper, lower, and two lateral boundaries of this region must be memorized. The upper boundary is the third rib, the lower is a horizontal line passing through the fifth intercostal space; the left lateral boundary is at or a little within the left mid-clavicular line, and the right lateral boundary is represented by a vertical line situated about a finger's breadth to the right of the right margin of the sternum. As the volume of the heart varies, within certain limits, in

different healthy persons, the boundaries of the precordia are, of course, not always exactly the same. The foregoing statements are sufficiently accurate for practical purposes.

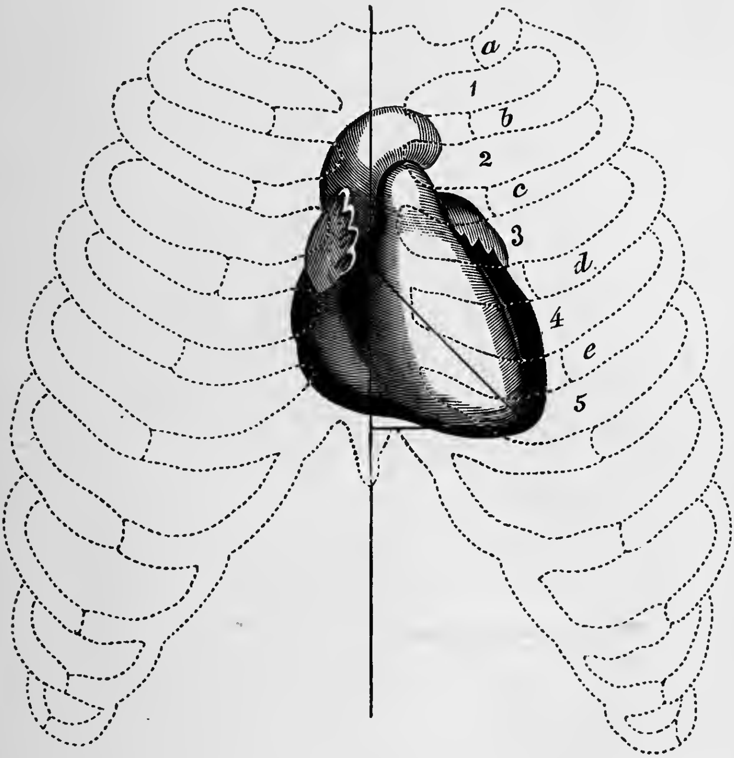
The horizontal line representing the lower boundary of the precordia intersects the point where the apex-beat of the heart is felt. The normal situation of the apex-beat must be recollected. In most healthy persons the apex-beat is felt in the fifth intercostal space, a little within the mid-clavicular line. This is assuming the persons to be sitting or standing; in recumbency on the back the beat sometimes rises to the fourth intercostal space, and it is sometimes found in the fourth space in the sitting or standing position of the body. The distance from the mid-clavicular line varies in different healthy persons; it is sufficiently accurate to say it is a little within that line (Fig. 9).

In changing a patient from the left lateral recumbent to the right lateral position it may be determined by palpation and percussion that the apex of the heart moves a half to one and a half inches to the right in healthy people.

The use of the orthodiagraphic method of examining the heart in action, has brought about a readjustment of our ideas as to the probable accuracy of topographical percussion of the heart. Although percussion will still be considered a necessary and useful method of examining the heart, the highest standard of accuracy will demand the use of the orthodiagram.

The force of the apex-beat varies much in different healthy persons, owing to other causes than the power of the heart's action, such as the amount of muscular substance and fat in that situation, the width of the

Fig. 9



intercostal space, the convexity of the chest, the relation to the left lung, etc. Allowance is to be made for these variations in determining the abnormal modifications of the force of the beat, which belong among the physical signs of disease.

Within a portion of the precordia the heart is uncovered of lung, and in the remaining portion lung intervenes between the heart and the walls of the chest. The former of these portions is called the superficial and the latter is called the deep cardiac space. The

Fig. 10

deep cardiac space on the right side extends to the median line. On the left side the lung recedes at a point on the median line on a level with the cartilage of the fourth rib, and the anterior border of the upper lobe makes an outward curve, returning inward at

or near the apex of the heart. This leaves the heart uncovered within an area which, for practical purposes, may be represented by a right-angled triangle, the hypotenuse extending from the median line on a level with the costal cartilage of the fourth rib to the apex of the heart; the right angle formed by the median line and the horizontal line which forms the lower boundary of the precordia (Figs. 9 and 10).

The limits of the superficial cardiac space may be easily defined by percussion. It is only necessary to ascertain the curved line formed by the receding anterior border of the upper lobe of the left lung. A distinct, although not great, dulness on percussion marks this border of the lung. The border of the lung is as distinctly marked by the abrupt diminution of the vocal resonance, if auscultation be made with the stethoscope. The outer boundaries of the deep cardiac space may also be determined by percussion; distinct, although slight dulness marks the limits of the precordia. Defining thus the boundaries of the precordia and of the superficial cardiac space in healthy persons, makes a good practical exercise in percussion. Distinct though slight dulness may usually be made out in the fourth space to the right of the sternum as far as three-quarters of an inch from the sternal border.

Relations of the Aorta and Pulmonary Artery to the Wall of the Chest.—The base of the heart, especially in connection with auscultatory signs, is generally considered to be at the second intercostal space near the sternum, this situation being, in reality, just

above the base. In this situation sounds produced at the aortic and the pulmonic orifice are best studied, either in health or disease. With reference to these sounds, the anatomical relations of the aorta and the pulmonary artery to the right and the left second intercostal space are of importance. If the stethoscope be applied in the second intercostal space on the right side, close to the sternum, it is very near the aorta, and sounds produced at the aortic orifice are best heard in this situation. If the stethoscope be applied in the second intercostal space on the left side, it is very near the pulmonary artery, and the sounds produced at the pulmonic orifice are best heard in this situation. Reference will be made to these two situations in giving an account of the heart-sounds in health and disease, and of adventitious sounds or murmurs (Fig. 9).

The Heart-sounds.—It is customary to consider the heart-sounds as two in number, and to distinguish them as the first, or systolic, and the second, or diastolic, sound. The characters which distinguish the heart-sounds in health are to be studied preparatory to the study of the abnormal modifications which are important physical signs of disease. It is essential to be able always to make the distinction practically between the so-called first, or systolic, and the second, or diastolic, sound in order to connect with them separately cardiac murmurs. The conventional use of the term heart-sounds, as distinguished from cardiac murmurs, must be borne in mind. The cardiac murmurs are adventitious sounds; they

are never merely abnormal modifications of the heart-sounds, but they are new sounds added to or replacing these.

Considering the heart-sounds as two in number, namely, the first, or systolic, and the second, or diastolic, these follow in a certain rhythmical order, and, in health, this suffices for the recognition of each. It answers all practical purposes to say that the sounds follow each other after an interval which is just appreciable, this interval being the short pause of the heart. After the occurrence of both, an interval is readily appreciable, called the long pause of the heart. It is not necessary to carry in the memory the exact relative duration of each of the two sounds and each of the two intervals. The fractions of a unit, in fact, do not express the length of the sounds and intervals as correctly as less definite expressions, inasmuch as the figures represent only the mean of variations within the limits of health. It is sufficiently exact to say that, with the ear or stethoscope applied over the situation of the apex-beat, the systolic sound is longer than the diastolic, louder, lower in pitch, and has a quality which may be called booming. *Per contra,* the diastolic sound is shorter, weaker, higher in pitch, and has a quality which may be called valvular or clicking. Aside from the relative length, the other characters are more or less marked in different healthy persons.

A third heart-sound is heard at the apex in about 65 per cent. of people under forty when they are placed in the recumbent and left lateral positions. This

heart-sound which is softer and of lower pitch than the second sound, occurs early in diastole and follows the second sound of the heart by about one-tenth to two-tenths seconds. This sound seems to be due to the sudden tension of the auriculo-ventricular valves, as a result of the first rush of blood from auricle into ventricle, in diastole (*vide* Thayer, Arch. Int. Med., 1909, vol. iv, No. 4).

These distinctive characters of the systolic and diastolic heart-sounds are apparent when the ear or stethoscope is applied over the apex. At the base of the heart, that is, in the second intercostal space near the sternum, the characters of the systolic sound are not the same as over the apex. The diastolic sound in this situation is louder than the systolic. The latter is said to be accentuated at the base, the systolic sound being accentuated at the apex. Moreover, the systolic at the base may not be longer than the diastolic; it loses more or less of its booming quality, the pitch remaining lower than that of the diastolic sound. Removing the ear or the stethoscope a certain distance from the apex in any direction, occasions similar changes in the characters of the systolic sound. The interposition of several thicknesses of a napkin has the same effect.

From the differential characters over the apex, and the rhythm alone in other situations, there is no difficulty in distinguishing the systolic from the diastolic sound in health. In cases of disease, however, owing to disturbance of the rhythm, modifications of the characters of the systolic sound, and the absence

sometimes of one of the sounds, other means of recognition must be resorted to. If the apex-beat can be felt, this offers a ready way for recognizing the systolic sound—the sound which is synchronous with the apex-beat is, of course, the systolic sound. This mode is not always available, inasmuch as the apex-beat cannot always be felt. Another mode is always available—namely, feeling the carotid pulse. The carotid pulse is synchronous with the systolic sound, whereas there is a slight interval between this sound and the radial pulse.

The student is aided in comprehending certain physical signs by taking into view the mechanism of the production of the heart-sounds. The diastolic sound is produced by the sudden forcible closure of the aortic and the pulmonic valves. This closure is caused by a retrograde movement of the columns of blood in the aorta and pulmonary artery, directly the ventricular systole is ended. The retrograde movement is due to the recoil of the coats of the arteries which have been dilated by the column of blood moving onward during the ventricular systole. This recoil causes regurgitation into the ventricle when either the aortic or the pulmonic valve is rendered incompetent by lesions.

The mechanism of the systolic sound is less simple. This sound is in part due to the forcible tension of the auriculo-ventricular valves, caused by the systole of the ventricles. In this way is produced a valvular element of the systolic sound. That the impulsion of the heart against the walls of the chest

furnishes another element, seems demonstrable. To this element of impulsion the systolic sound is indebted for its greater intensity, as compared with the diastolic sound, its length, and its booming quality. This is shown by the fact, already stated, that when auscultation is made at a certain distance from the apex, these characters are eliminated, and by the fact that diseases which diminish or arrest the impulsion movements of the heart produce the same modifications. The valvular element of the systolic sound is weaker than the diastolic sound, a fact which at first occasions surprise when the difference in size between the aortic and pulmonic and the auriculo-ventricular valves is considered.

The explanation of this apparent incongruity is as follows: The aortic and pulmonic segments at the end of the ventricular systole are in contact with the arterial walls, and are expanded when the recoil of the latter follows. On the other hand, when the ventricular systole takes place in health, the auriculo-ventricular valves are not in contact with the walls of the ventricles, but they are floated out, and the orifices are nearly or quite closed; the movement of the blood, therefore, in the systole only renders these valves tense. The diastolic sound, in other words, is due to the expansion of the sigmoid valves of the aorta and pulmonary artery, whereas, the valvular element of the systolic sound is due to tension of the auriculo-ventricular valves.

With reference to important bearing on auscultation in disease, the diastolic or second sound is to be

studied as produced at the aortic and the pulmonic orifices separately. Recalling the anatomical relations of the aorta and the pulmonary artery to the wall of the chest, if the stethoscope be applied in the second intercostal space on the right side close to the sternum, the characters of the diastolic sound are derived chiefly from the aortic valve, and if the stethoscope be applied in the second intercostal space on the left side close to the sternum, the characters of the diastolic sound are derived chiefly from the pulmonic valve. The correctness of this statement is proved by differences in the characters of the sound on two sides in health, and by the modification in cases of disease. These morbid modifications will enter into the physical diagnosis of cardiac affections. In health the aortic diastolic sound is somewhat louder, higher in pitch, and the valvular quality more marked than the pulmonic diastolic sound.

In patients under twenty years of age, the pulmonary second sound may be found to be equal to, or louder than the aortic second sound. Over the age of twenty, and usually to an increasing degree with advancing years, the aortic second sound is louder than the pulmonary second sound, owing, in all probability, in the main, to the increasing tension or blood pressure in the systemic arteries at maturity and after.

The student should verify these points of difference by the study of the diastolic sound in the two situations just named. In order for the comparison to be a fair one in health, and available in the diagnosis of disease, the normal anatomical relations to the wall

of the chest, of the aorta, and pulmonary artery must be preserved. These relations are affected by changes in the symmetry of the chest, and sometimes by enlargement of the heart. The lungs must also be free from disease; otherwise, the transmission of the sounds will be abnormal.

In the account of the mechanism of the production of the heart-sounds (*vide* page 231), it was stated that the first or systolic sound consists of a valvular element and an element of impulsion. This valvular element is a twofold sound, that is, it is a combination of a sound produced by the mitral and a sound produced by the tricuspid valve. These two synchronous valvular sounds may be studied separately in health, and their abnormal modifications constitute important diagnostic signs in cases of disease.

The two valvular sounds may be designated the mitral and the tricuspid systolic sounds. Adding to these two sounds, the sound of impulsion produced by the movements of the apex, with the ventricular systole, are three distinct sounds. The diastolic or second sound of the heart, as has been seen, is resolvable into two distinct sounds. Hence, the number of distinct heart-sounds is, in reality, five, two of which are diastolic and three systolic—namely, the mitral valvular, the tricuspid valvular, the sound of impulsion, the aortic, and the pulmonic. Each of these five sounds may be studied separately in health and disease. The abnormal modifications of each furnish important information in diagnosis.

In health, the sound of impulsion is heard over

the situation of the apex-beat of the heart. The mitral valvular sound is studied by listening with the stethoscope applied to the left of the apex at a distance sufficient to eliminate the sound of impulsion.

The tricuspid valvular sound is heard best at the end of the sternum or just to the left of this point.

In the pages which follow I shall sometimes refer to the systolic and the diastolic sound in the singular number, it being understood that the systolic sound embraces three, and the diastolic two, components; and at other times I shall refer to the sounds separately, which are combined in the two sounds.

The order of the succession of the movements of the auricles and of the ventricles is to be kept in mind, with reference to the comprehension of certain physical signs of disease. Points of special importance are the contraction of the auricles in the latter part of the long pause of the heart, preceding the ventricular systole, and the twisting of the heart from left to right in the systole, this movement being reversed in the diastole. In these systolic and diastolic twisting movements the visceral and parietal portions of the pericardium move upon each other, in health noiselessly, owing to their smoothness and moisture.

The movements occasion an auscultatory sign—namely, a friction murmur—when the surfaces are roughened by the presence of lymph. Other points are, the size of the pericardial sac, that is, its capability of holding when filled, but not dilated, from fifteen to twenty ounces of liquid, and its attachment, not to the base of the heart, but to the vessels above the base.

PHYSICAL CONDITIONS OF THE HEART IN DISEASE

The physical conditions of the heart in disease, which are determinable by physical exploration, are, (1) enlargement of the heart; (2) abnormal impulses and modifications of the apex-beat; (3) valvular lesions; (4) roughness of the pericardial surfaces; and (5) liquid within the pericardial sac. Having considered these conditions, an account of abnormal modifications of the heart-sounds and cardiac murmurs will conclude this chapter.

Enlargement of the Heart.—Enlargement of the heart may be slight, moderate, great, or very great, these terms expressing different degrees of enlargement with sufficient precision for clinical purposes. In cases of very great enlargement, the space within the chest which the heart occupies may be from four to five times larger than in health. The situation of the base of the heart remains but little, or not at all, changed in cases of enlargement; the increased space which the heart occupies is therefore downward. The increased space extends much more to the left than to the right; the left border of the heart, in proportion to the enlargement, is carried beyond the *mid-clavicular* line on the left side, whereas, the right border is carried comparatively but little beyond the normal right lateral boundary of the precordia even when the enlargement is very great.

The cardiac dulness may be increased in all directions

or only in one direction. We naturally attribute a dislocation of the left border of cardiac dulness to the left, to enlargement of the left ventricle; a dislocation of the right border to the right, to enlargement of the right ventricle; an increase upward, to dilatation of the auricles or of the great vessels. Cardiac dulness may be found as far to the right of the sternum in the third and fourth spaces, in dilatation of the right auricle and ventricle in tricuspid insufficiency, as it is found normally to the left of the sternum.

The superficial cardiac space is enlarged in proportion to the enlargement of the heart; the organ pushes to the left the receding anterior border of the upper lobe of the left lung, and is proportionately in contact, uncovered of lung, with the wall of the chest. The apex of the heart is lowered in proportion to the enlargement, and it is carried more or less to the left of its normal situation. It may be lowered to the sixth, seventh, eighth, or ninth intercostal space. The enlargement of the heart is rarely equal in all its parts. The ventricular enlargement may be entirely, or chiefly, of either the right or the left ventricle. Enlargement of the right ventricle tends to carry the right side of the heart more to the right than when the left ventricle is enlarged. The situation of the apex is also affected by the parts of the heart in which the enlargement predominates. The apex is carried farther to the left of its normal situation, other things being equal, when the enlargement predominates on the right side of the heart; and it is lowered, without being carried far to the left, when the enlargement of

the left ventricle predominates. The apex of the organ, in cases of considerable, or of great enlargement, becomes changed in form; it is rounded or blunted. This change is most marked when enlargement of the right ventricle predominates. All these points are of importance with reference to the comprehension of the physical signs of enlargement of the heart.

Enlargement of the heart may be due, entirely either to hypertrophy or to dilatation (simple hypertrophy and simple dilatation). If, however, the enlargement be sufficient to occasion notable disturbance of the circulation, both these forms of enlargement are combined, but, as a rule, one or the other form predominating, so that, of the cases of diseases of the heart which come under medical treatment, the majority are cases of either enlargement with predominant hypertrophy, or enlargement with predominant dilatation.

These widely different physical conditions are concerned especially in the abnormal impulses and modifications of the apex-beat, as well as, also, the heart-sounds.

Abnormal Impulses of the Heart, and Modifications of the Apex-beat.—The abnormal situation of the apex of the heart when enlarged has been stated. Generally the situation is determinable by the apex-beat. It has been seen that in health the beat is sometimes not appreciable by the touch, owing to the thickness of the soft parts, and the conformation of the thorax, and, for these reasons, the force of the beat varies much in different healthy persons. Exclusive of

normal variations, the beat is generally strong and prolonged, in proportion as the heart is enlarged by hypertrophy. There are exceptions to this statement, which are to be explained by the altered form of the apex; when it loses its pointed form it does not so readily come into contact with the walls of the chest in an intercostal space, and, hence, the beat may be weak although the ventricular systole be abnormally strong. On the other hand, the apex-beat is weakened by dilatation, and it may be wanting, as a result of diminished strength of the systole of the ventricles. The apex-beat is also abnormally weak in fatty degeneration and softening of the heart, as well as in functional debility of the organ, incident to other diseases than those of the heart.

If there be considerable or great enlargement, the heart being in contact with the wall of the chest over a larger area than in health, impulses other than the apex-beat are generally apparent to the eye and touch. Not frequently impulses are appreciable in each intercostal space between the situation of the apex and the base of the heart. These abnormal impulses are felt to be strong in proportion as the enlargement is due to hypertrophy, and weak in proportion as dilatation predominates. Enlargement seated in the right ventricle causes an impulse in the epigastrium which is strong or weak in proportion as hypertrophy or dilatation predominates. Cardiac impulses are felt and seen in abnormal situations when the heart is removed from its normal situation by the pressure of an aneurism, or other tumor, by

pleuritic effusion, hydroperitoneum, etc. The error of mistaking for a cardiac impulse the pulsation of an aneurismal tumor is to be avoided. Another error is to be avoided—namely, mistaking abnormal impulses due to the heart being uncovered of lung, from shrinking of the latter in certain pulmonary affections, for impulses denoting enlargement of the heart. In cases of enlargement by hypertrophy, a heaving movement of the whole precordia is sometimes felt when the hand is applied to the chest. A violent shock is sometimes felt by the hand applied to the precordia, but without a sense of increased muscular power, in cases of purely functional disorders of the heart. Because of pericardial adhesions, or due to enlargement and displacement of the heart, a systolic retraction may be seen where we should expect a systolic impulse, and a diastolic impulse or retraction may appear, and demand close attention to be located with reference to its place in the cardiac cycle.

Valvular Lesions.—The lesions affecting the valves of the heart are of a varied character, for an account of which the student is referred to treatises on cardiac diseases, or on pathological anatomy. It suffices here to consider that, with reference to physical signs and pathological effects, they may be distributed into three groups, as follows: (1) Lesions which diminish more or less the size of the orifices, or obstructive lesions; (2) lesions which render the valves more or less incompetent and permit regurgitation, or regurgitative lesions; and (3) lesions which roughen the surfaces over which the blood moves without occasioning

either obstruction or regurgitation. The latter may be distinguished as innocuous lesions, giving rise to no pathological effects although represented by cardiac murmurs.

It is to be borne in mind that in the great majority of cases valvular lesions are seated in the left side of the heart, that is, they are either mitral or aortic. Tricuspid and pulmonic lesions are comparatively rare, and they are generally congenital. Not infrequently mitral and aortic lesions coexist, and there may be coexisting lesions at all the orifices of the heart.

Valvular lesions are represented by cardiac murmurs. By means of the murmurs the existence of lesions is known, their situation at the different orifices may be ascertained, and, generally, it is practicable to determine whether they occasion obstruction or regurgitation, or both. These several points of inquiry will be considered presently under the heading Cardiac Murmurs, and in connection with the lesions of the different valves respectively in the next chapter.

Roughness of the Pericardial Surfaces.—In place of the smoothness of the pericardial surfaces in health, which permits their movements upon each other noiselessly, the presence of the inflammatory product, lymph, and, in some rare instances, morbid growths, occasion an adventitious sound or murmurs, which will be noticed in connection with other murmurs, and as entering into the physical diagnosis of pericarditis.

Liquid within the Pericardial Sac.—More or less liquid transudes into the pericardial sac in cases of general

dropsy or anasarca, but rarely in very large quantity. Liquid effusion occurs in acute pericarditis, and in this affection the sac may become filled with serous or purulent liquid. In some cases of chronic pericarditis the sac is greatly dilated by liquid, the quantity amounting to four pounds, or even more.

When the pericardial sac is filled with liquid, without being dilated, it forms a pyriform tumor within the chest, the base of which is at the sixth or seventh intercostal space; the apex rises nearly to the sternal notch; the left lateral border is considerably beyond the nipple, and the right lateral border is more or less beyond the right margin of the precordia. The anterior portion of the filled pericardium is mostly uncovered of lung and in contact with the wall of the chest. Within this area there is either notable dulness or flatness on percussion, together with absence of respiratory murmur and of vocal resonance. By means of these signs, the boundaries of the pyriform tumor may be readily delineated on the surface of the chest. The difference in form and situation of the area of dulness or flatness on percussion in cases of large pericardial effusion, from the area in cases of enlargement of the heart (*vide* page 236), is to be noted and borne in mind with reference to the differential diagnosis.

When the pericardial sac is partially filled with liquid, the same signs are present, but within an area of less extent, and the configuration of the pyriform tumor is wanting.

In cases of chronic pericarditis with a large accu-

mulation of liquid, the pericardial sac is dilated so that its lateral boundaries may extend nearly to the axillary and infra-axillary regions, and the pyriform shape is usually lacking, the outline being more nearly globular. Under these circumstances, flatness on percussion, absence of respiratory murmur and of vocal resonance, are present over the greater part of the anterior aspect of the chest.

ABNORMAL MODIFICATIONS OF THE HEART-SOUNDS

In order to appreciate the abnormal modifications of the heart-sounds, their normal characters are to be kept in mind (*vide* page 228), and the student must be practically familiar with them. The modifications relate to the three components of the systolic sound, and to the two components of the diastolic sound, collectively and separately.

The sound of impulsion, as heard over the apex, is intensified in hypertrophy of the heart. This sound is not only notably loud, but prolonged, and its booming quality is marked. It sometimes has a ringing tone, called tinnitus. The systolic valvular sounds—namely, the mitral and the tricuspid—are also more or less increased in intensity. The increased intensity of either the mitral, or the tricuspid valvular sound, separately, denotes that the hypertrophy is seated especially in either the left or the right ventricle.

In some cases of violent palpitation the systolic

sounds are notably intensified, the sound of impulsion being comparatively weak. I suppose the explanation to be as follows: the ventricles contract with a kind of spasmodic action upon a small quantity of blood; and, under these circumstances, the auriculo-ventricular valves, not being floated out as they are when the ventricles are well filled, expand with force in the ventricular systole, instead of being merely made tense, as in health. Hence, the valvular sounds are intensified, while the sound of impulsion may be feeble or wanting. The sound of impulsion over the apex is weakened or lost, as an effect of those affections of the heart, which diminish the power of the ventricular systole. These affections are enlargement from dilatation, atrophy, fatty degeneration, myocarditis, obstruction of the coronary arteries, and softening. The systolic valvular sounds are also more or less weakened, but in a less degree than the sound of impulsion. The loss of the sound of impulsion over the apex renders the so-called first, or systolic sound of the heart, short and valvular in quality.

Liquid effusion within the pericardium renders the sound of impulsion over the apex more or less weak. If the liquid effusion be large, only the systolic valvular sounds—namely, the mitral and tricuspid—are appreciable. Diminished power of the heart's action from other than cardiac diseases, involves weakness of all the heart-sounds, but more especially of the sound of impulsion.

Abnormal modifications of the diastolic sound relate to the aortic and pulmonic sounds considered

separately. Bearing in mind the mode of interrogating the aortic and the pulmonic orifice with reference to the valvular sound derived from each independently of the other (*vide* page 233), a comparison of the two sounds in diseases of the heart affords often useful information. Whenever, from mitral obstructive or regurgitant lesions, or both combined, or from obstruction at the aortic orifice, the quantity of blood propelled by the left ventricle into the aorta is diminished, the recoil of the arterial coats, after the ventricular systole, is lessened; consequently, the aortic segments expand with less force, and the aortic sound is weakened. Diminished intensity of the aortic sound thus represents an abnormal diminution of the quantity of blood propelled into the systemic arteries by the systole of the left ventricle, and this diminished intensity of sound is, in a measure, a criterion of the amount of mitral obstruction or mitral regurgitation, or both combined, or of aortic obstruction. In some cases of great obstruction or regurgitation the aortic sound is completely suppressed. How is weakening of this sound to be determined and measured? By comparison with the pulmonic sound. Now, as will presently appear, the pulmonic sound is often intensified when the aortic sound is weakened. Hence, the former is not an accurate standard for this comparison; but it suffices for an approximation to accuracy. In cases of hypertrophy of the left ventricle without obstruction, or regurgitant valvular lesions, the aortic sound is abnormally intensified, owing to increased arterial blood pressure, which is,

in most instances, secondary to fibroid, or atrophic, lesions of the kidneys. Intensification of the aortic sound may be due to increased tension in the systemic arteries without cardiac hypertrophy.

A simpler cause of weakening or suppression of the aortic sound, is damage from lesions of the aortic valve. In proportion as the function of this valve is impaired by lesions, the intensity of the sound is diminished, and if the function of the valve be lost, the sound is wanting. In these cases, the pulmonic sound being but little or not at all affected, it is an accurate standard for the comparison.

The pulmonic sound is weakened in the rare instances of lesions affecting the pulmonic valve. This sound is oftener intensified than weakened. It is notably intensified when the right ventricle is hypertrophied, and especially when this hypertrophy is associated with dilatation of the left auricle resulting from mitral obstruction or regurgitation. These lesions weakening, as has just been seen, the aortic sound, the contrast between the aortic and the pulmonic sound in some cases of mitral lesions is very marked. The pulmonic sound is sometimes loud, while the aortic sound is suppressed.

Increased tension of the pulmonary arterial system may increase the intensity of the pulmonic sound, irrespective of hypertrophy of the right ventricle. This increased tension is due to whatever cause obstructs the pulmonary circuit, *i. e.*, whatever puts obstruction in the way of the right ventricle whether this be obstructed or regurgitated blood at the mitral

orifice, paralysis of the left auricle, or mechanical obstruction of the pulmonary veins, capillaries, or arteries in the lung as the result of consolidation, fibrosis, bronchial spasm, emphysema or defective expansion of the thorax. The pulmonary second sound is also intensified in cases of palpitation and excitation of the heart by exercise and emotion.

In comparing the aortic and the pulmonic sound in disease, as in health, it is to be assumed that the anatomical relations of the aortic and the pulmonary artery to the second intercostal space on either side, close to the sternum, are not materially altered, and that the lungs are free from lesions, in consequence of which the conduction of the sound on either side is abnormal.

Returning to the systolic group of sounds, the mitral and the tricuspid sound may be studied separately. With the stethoscope applied at or a little to the left of the apex, the valvular sound which is heard, is derived from the mitral valve. On the other hand, if the stethoscope be applied at, or to the left of, the end of the sternum, the valvular sound is derived from the tricuspid valve. Notable weakness or suppression of the mitral sound, as compared with the tricuspid, represents impairment of the function of the mitral valve, and, *per contra*, notable weakness, or suppression of the tricuspid sound, denotes impairment of the function of the tricuspid valve. Allowance, in this comparison, is to be made for a normal disparity, the mitral sound being louder than the tricuspid in health.

Reduplication of Heart-sounds.—The sounds of the heart are said to be reduplicated, when either the systolic or the diastolic sounds are repeated, or when both occur twice, before the long pause or interval. Considering the heart-sounds as twofold, that is, systolic and diastolic, and as represented by the whispered words Lub-dup, reduplication of the systolic sound is expressed by Lublub-dup, of the diastolic by Lub-dupdup, and of both by Lublub-dupdup.

Clinically, reduplication of the diastolic is observed much more frequently than reduplication of the systolic sound. In other words, the pulmonic and aortic sounds, instead of being synchronous, occur in succession. This may occur when the systolic sounds occur synchronously. The explanation is, that from increased tension of either the systemic or the pulmonic arteries (oftener the latter), the recoil of the arterial coats after the systole, and the extension of the sigmoid valves, take place, in one artery sooner than in the other. If both the systolic and the diastolic sounds be reduplicated, the explanation which seems most rational is, that the two ventricles contract, not in exact unison, but that one contracts a little before the other. In systolic reduplication the mitral and the tricuspid sounds occur in succession, instead of occurring synchronously. The sound of impulsion is not reduplicated.

There is a form of functional disorder which may be confounded with reduplication of both sounds of the heart. In this disorder, with every alternate revolution of the heart, the sounds are weak, and

the ventricular systole is not represented by a radial pulse, the force of the contraction of the ventricle being insufficient to cause an appreciable pulsation in the remote arteries; hence, the heart-sounds occur twice for each pulse at the wrist. Under these circumstances, however, the carotid pulse may generally, if not always, be felt with the weak, as well as with the stronger, ventricular contraction, and in this way the error of confounding the disorder with reduplication may be avoided. The type of arrhythmia here described is now known to be due to extra-systole, *i. e.*, the ventricles of the heart alone participate in an extra contraction, which can be heard, and gives a palpable pulse wave or not according to the strength of the contraction.

Reduplication of the heart-sounds may occur in connection with cardiac lesions, or there may be no evidence of any organic affection. In the latter case the anomaly falls properly among the varied forms of functional disorder of the heart. Whether, or not, it be connected with lesions, it has no important pathological significance. It is usually of temporary duration.

THE PULSE

An examination of the arterial pulse is an essential in every examination of a patient. We note its occurrence at various parts of the body, in the temporals, carotids, brachials, radials, femorals, popliteals, and in the dorsalis pedis. We observe its comparative

qualities on the two sides of the body. We pay particular attention to its characteristics at the radial or brachial in each arm. It is taken for granted that the student understands fully the rather complex neuro-muscular mechanism, which determines the incidence and rate of cardiac contractions, and the laws of hemo-dynamics, which determine the various characters of the venous and arterial pulses at the periphery. For full information the student is referred to recent special works on the heart and pulse.

Frequency.—We note the frequency of the pulse in the minute, observing variations from the physiological limits, according to the age of the patient. An infrequent pulse may follow great bodily exertion, convalescence from severe diseases, malnutrition, in vomiting, during vagus stimulation, in cerebral compression, and in aortic stenosis alone among the valvular defects of the heart.

If the auricles of the heart beat two, three, or more times as often as the ventricles (heart-block), we note the lack of relation by combined auscultation and palpation; or by observing the auricular venous pulse in the neck, while palpating the carotid, or radial artery, or the apex beat. A particularly slow pulse may occur during the physiological effect of digitalis.

If the pulse be markedly irregular, its frequency may be decidedly less than the frequency of the ventricular contractions. In this case, auscultation of the heart sounds, or palpation of the apex beat, should always be combined with palpation of the radial pulse. The difference between the ventricular

rate and the radial pulse rate is spoken of as the pulse deficit. Followed from day to day, the record of the pulse deficit gives valuable evidence of the effect of treatment in improving the efficiency of the ventricles.

Inequality in the size and force of pulse beats necessarily accompanies irregularity in the intervals which separate them, a long diastolic interval being followed by a large pulse-wave, and a short interval by a small pulse-wave.

The exact study of the irregularities of the pulse has become of great practical importance. For their complete recognition, tracings of the arterial and venous pulses, or records of the electrical changes accompanying cardiac contraction, are necessary, although the main distinctions may be made by the finger (*vide* Chapter XII).

A frequent pulse may be due to muscular activity, exhausting diseases, and debilitated states. It is almost always found in fever, in vagus paralysis, in the last stage of cerebral pressure or basilar meningitis, in neurotic and toxic states, and in exophthalmic goitre, and as an important sign of weak heart muscle, in almost all cardiac, valvular defects when compensation is failing and where there is vaso-motor paresis, or collapse. Excessive frequency, occurring in attacks, may be observed at intervals for years, usually without apparent cause (paroxysmal tachycardia).

Regularity.—We note the regularity of the pulse, as affecting its force and frequency.

The irregularities of the pulse are as follows:

1. Complete loss of the dominant rhythm, the intervals being wholly irregular, and the beats unequal. This is called *the perpetually irregular pulse,* and is usually characterized by excessive frequency as well. It indicates complete failure of the normal auricular contractions, the auricles being in the state called fibrillation. The jugular venous pulse is always systolic in time. This type of irregularity may persist for years, but always denotes serious damage to the heart muscle. Among the valvular defects, it is most commonly found with mitral obstruction.

2. Occasional interruption of a regular pulse by premature heart-beats, usually single, rarely in groups. Such premature heart-beats are called *extra-systoles.* They may occur at long intervals, or as often as every other beat. When the latter, the rhythm is called *bigeminy,* or coupled-beats, a condition characteristic of the early toxic effect of digitalis. Extra-systoles are not in themselves of serious significance. Occasional extra-systoles are common toxic results of tobacco, coffee, and other poisons. They occur in severe fatigue, in persons with high blood-pressure, and without evident cause.

3. Occasional complete omission of a heart-beat, the true *intermittent pulse.* If the first heart-sound is also absent, this indicates a temporary heart-block, and is seen also during the use of digitalis. If there is a first heart-sound, but no radial pulse, it indicates an extra-systole which was not of sufficient force to open the aortic valve.

4. Occasional sudden change from a normal rhythm to a regular rhythm of approximately double the rate, the rapid rhythm being maintained for a few beats, to hours or even days, and usually returning abruptly to the previous normal rate. This is true *paroxysmal tachycardia.*

5. Moderate variation in the rate of the dominant rhythm, synchronous with respiration, is normal in children and in many adults. This is called the respiratory irregularity, or *sinus arrhythmia,* as it depends upon the varying rate of discharge of impulses from the sinus node, the normal pace-maker of the heart. Similar variation in the dominant rhythm occurs in excitement, and may be marked in meningitis. It is due to stimuli received by the heart through the vagus nerves, and never signifies disease of the heart muscle.

6. Alternation of large and small beats, without noticeable variation in the intervals which separate them, constitutes the *alternating pulse.* It is to be carefully distinguished from bigeminy, for it signifies serious exhaustion of the contractile power of the heart muscle.

Inspiration may cause decrease in the size and frequency of the pulse, in cases of inflammations and tumors of the mediastinum (pulsus paradoxus).

Inequality of force upon the two sides may be due to abnormalities in the size of the arteries upon one side, or to pressure as by an aneurism of the aorta.

Size.—We note the size of the pulse. The pulse is large or small according to the amount of blood deliv-

ered to the great vessels during ventricular systole, as modified by the condition of tonus of the vessels, between the heart and the point of palpation of the artery. We find a large pulse often in hypertrophy of the left ventricles, especially in aortic regurgitation, in compensated high blood pressure of nephritic origin, and often in the sthenic stage of fevers. We find the pulse small in syncopal attacks, in cardiac muscular weakness, in stenosis of any cardiac valvular orifice, particularly in mitral and aortic stenosis, and during chills.

Rapidity.—We note the rapidity with which the pulse fills and empties (or the celerity). We find a quick pulse in the collapsible pulse of aortic insufficiency (the water-hammer or Corrigan pulse), and where we have a relaxed arterial wall at the same time that the heart is overacting, as in the asthenic stage of fevers. We have a slow pulse in aortic stenosis, and where we have high peripheral resistance and no disturbance of the reflex nervous control of the heart.

Tension.—We note the sense of resistance or tension of the pulse as appreciated by applying the tips of three fingers to the artery, and noting the pressure needed at the proximal finger to prevent the appreciation of the pulse by the distal finger. Although we may get a general impression of the tension by palpation, this is a matter so easily determinable, and so exactly, both for the systolic and diastolic phase of the pulse, by the use of apparatus for estimating blood pressure, that this method should supplement the manual palpation wherever possible.

A hard pulse is with difficulty obliterated by digital pressure. Nephritis of the chronic type and advanced arteriosclerosis usually exhibit a hard pulse.

A soft or easily compressible pulse is found in fever, anemia, weakness of the heart muscle, and in vaso-motor paresis.

Character of Arterial Wall.—We note the character of the arterial wall, *i. e.*, whether the arterial wall is palpable or not, when the pulse is obliterated by pressure farther up the arm. The normal radial artery is not palpable when empty. A firmly contracted artery is to be distinguished from an artery with an hypertrophy of its muscular wall, and both of these conditions from a smooth fibrous replacement in the wall, or, what is easier, from the so-called pipe-stem artery with nodular calcareous deposits. These are appreciated by rolling the vessel under the finger tips, or the edge of the nails.

Capillary Pulsation.—The capillaries may show systolic pulsation in aortic regurgitation. This may be seen as a faint pulsation if a microscope slide be pressed against the muco-cutaneous margin of the lower lip, just hard enough to blanch the skin, or if the end of the nail is bent, to the point of blanching the pulp beneath, or in the systolic flushing of a line drawn across the forehead by the finger.

Pulsation of the Cervical Veins.—A systolic pulsation is normally seen in the majority of people in the external jugular veins for about three-quarters to an inch above the clavicle. The impulse is seen best on the right side, and is synchronous with auricular

contraction. The pulsation in the veins is visible, but very rarely appreciable by the touch. It is to be distinguished from pulsation of the arteries of the neck. This is easily done by finding that pressure just above the clavicle, sufficient to interrupt the flow of blood in the veins, but not in the arteries, abolishes the pulsation. A venous pulse when excessive is generally due to a tricuspid regurgitant current, and is therefore caused by the contraction of the right ventricle. If caused by the contraction of the right ventricle in tricuspid regurgitation, the venous pulse is synchronous with the carotid pulse, the systolic sounds of the heart, and the apex-beat. If caused by the contraction of the right auricle, the venous pulse precedes the carotid pulse; it is presystolic. A venous pulse, thus, may be either ventricular or auricular, and the differentiation is easily made. There may be both a ventricular and an auricular venous pulse, the one synchronous with, and the other preceding, the carotid pulse. Pulsation is sometimes observed in other veins than those of the neck—the brachial, femoral, and even veins still more remote from the heart.

CARDIAC MURMURS

All adventitious abnormal sounds which are added to the heart-sounds, are embraced by the term cardiac murmurs. Let it be borne in mind that, conventionally, the murmurs are never abnormal modifications of the heart-sounds, but always newly produced sounds, and they always represent morbid conditions

of either the heart or the blood. When due to morbid conditions of the blood, they are called inorganic, anemic, or hemic murmurs, and when they represent valvular lesions or changes within the heart, they are distinguished as organic murmurs.

In fevers, as of the acute infectious diseases, or in high temperature from various other causes, we commonly find a systolic murmur at the apex corresponding to the murmur of mitral regurgitation. This may be heard also in marked anemia and in extreme asthenia, and this murmur may properly be called a functional murmur, as it seems to be due to an atonic or relaxed condition of the mitral ring, and to a lack of proper functioning of the papillary muscles.

A systolic murmur heard over the base of the heart, especially at the second left interspace, seems to be due to a dilatation of the conus arteriosus, and is found to occur not infrequently in fever, and anemias, and from unexplained causes.

In healthy adults there is, not uncommonly, during expiration, a systolic murmur heard over the base of the heart, and disappearing during inspiration. This is usually more easily heard in those with flat chests. It is rather common in children. The important distinguishing point about this murmur is its dependence upon the expiratory phase of respiration. Its causation is not well understood.

There are other accidental murmurs, usually systolic, but occurring also in any part of the cardiac cycle, of which the cause is uncertain and the importance negligible.

The murmurs may be distributed into three groups after differences in quality, namely: (1) soft; (2) rough; and (3) musical murmurs. The soft murmurs resemble the sound produced by air from the nozzle of a pair of bellows, and, hence, are often called bellows murmurs. Murmurs are said to be rough when their qualities may be expressed by such terms as rasping, grating, creaking, croaking, etc. They are called musical when the sound is a musical note. The bellows murmurs are the most frequent, and the musical are more rare than the rough murmurs. The quality of a murmur does not in general invest it with any special pathological or diagnostic significance. The murmurs vary in pitch, being either relatively high or low. The variations in pitch are useful in aiding to discriminate different coexisting murmurs.

This account of murmurs applies to those produced at the orifices or within the cavities of the heart. They are distinguished as endocardial murmurs. Adventitious sounds are, however, produced upon the external surface of the heart. These constitute exocardial, pericardial, or friction murmurs.

Endocardial murmurs are produced by blood-currents pursuing either a normal or an abnormal direction. With a familiar knowledge of these currents, and of their relations with the heart-sounds, the several endocardial murmurs are very easily understood, as regards points involved in their differentiation from each other. The student is, therefore, advised first to become acquainted with the blood-currents in health and in disease. Directing the attention to

the left side of the heart, there are two normal blood-currents—namely, the current from the left auricle to the left ventricle, and the current from the left ventricle into the aorta. These may be distinguished as the direct currents. The first is the mitral direct current, and the second is the aortic direct current. Two abnormal currents may occur in the left side of the heart. These currents can only take place when the valves are rendered incompetent by lesions. The incompetency of the valves allows of regurgitation, and these abnormal currents may be distinguished as the regurgitant currents. One of these is a current backward from the left ventricle into the left auricle, owing to incompetency of the mitral valve; this is the mitral regurgitant current. The other is a current backward from the aorta into the left ventricle, arising from incompetency of the aortic valve; this is the aortic regurgitant current (Figs. 11 and 12).

What are the relations of the four currents in the left side of the heart with the heart-sounds? The mitral direct current takes place when the auricles contract. The contraction of the auricles precedes the ventricular systole. The ventricular systole is synchronous with the systolic sounds of the heart. The mitral direct current, therefore, takes place just before these sounds. It begins after the diastolic sounds, and continues until it is suddenly and completely arrested by the contraction of the ventricle. It is, therefore, presystolic. It is obvious that the current cannot continue during the ventricular contraction, that is, when the first systolic sounds of the

Fig. 11

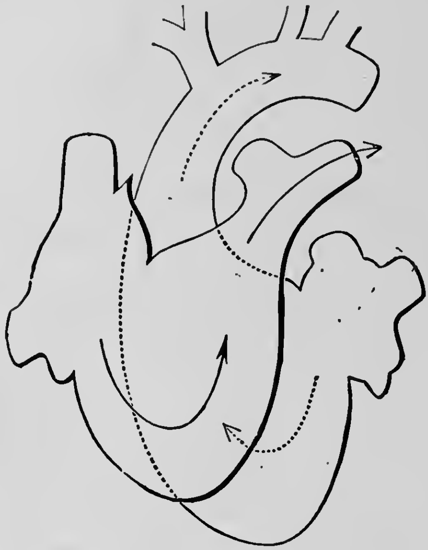


Diagram representing the normal blood-currents.
Plain arrows represent currents in right side of heart. Dotted arrows represent currents in left side of heart.

Fig. 12

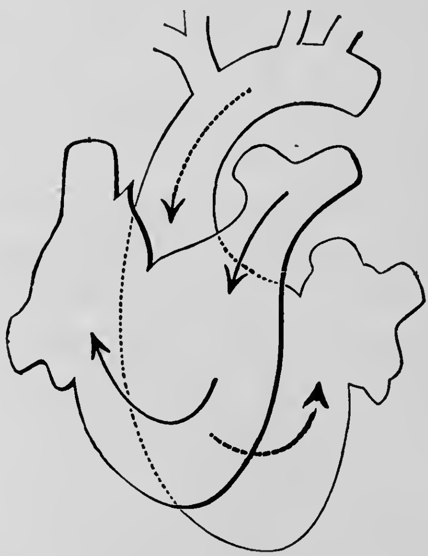


Diagram representing the abnormal blood-currents.
Plain arrows represent currents in right side of heart. Dotted arrows represent currents in left side of heart.

heart are produced. The mitral regurgitant current is caused by the contraction of the ventricle; the currrent, therefore, must take place with the systolic sounds of the heart. The aortic direct current, being caused by the contraction of the left ventricle, takes place with the systolic sounds of the heart. It is, therefore, coincident with the mitral regurgitant current. The aortic regurgitant current is caused by the recoil of the arterial coats upon the column of blood within the aorta, directly after the ventricular systole, and as this recoil causes the diastolic aortic sound of the heart, the current and this sound must be coincident or the diastolic aortic sound is wholly replaced by the sound of the regurgitant current.

Recapitulating the relations of the four currents with the heart-sounds, the aortic direct and the mitral regurgitant take place with the systolic sounds—they are systolic currents. The mitral direct current precedes the systolic sounds—it is presystolic; and the aortic regurgitant current takes place with the diastolic sound—it is diastolic.

Analogous blood-currents take place in the right side of the heart, and have corresponding relations with the heart-sounds. These currents are the tricuspid direct, the tricuspid regurgitant, the pulmonic direct, and the pulmonic regurgitant. The pulmonic regurgitant is exceedingly rare in consequence of the infrequency of pulmonic lesions; but the tricuspid regurgitant is not uncommon, and occurs without valvular lesions or enlargement of the heart when the right ventricle is distended with blood, constituting

what has been called the "safety valve function" of the tricuspid orifice.

Organic endocardial murmurs are produced by the foregoing direct and regurgitant blood-currents, and they are designated by the same names, that is, they are either direct or regurgitant. Thus, there are produced in the left side of the heart—the side in which valvular lesions are seated in the great majority of cases—a mitral direct murmur, a mitral regurgitant murmur, an aortic direct murmur, and an aortic regurgitant murmur. In the right side of the heart there may be produced corresponding murmurs—namely, a tricuspid direct, a tricuspid regurgitant, a pulmonic direct, and a pulmonic regurgitant. It remains to point out the means of differentiating these several murmurs, aside from their relations with the heart-sounds.

Mitral Direct or Presystolic Murmur.—This murmur begins after the diastolic sounds and ends abruptly with the systolic sounds. Almost invariably, this murmur is rough in quality; occasionally, it is a soft bellows murmur. When rough, it is often quite loud. The rough quality is peculiar; it is suggestive of vibration, and may be imitated by causing the lips or the tongue to vibrate with the breath in expiration. I state the mechansim of this murmur, inasmuch as the explanation is original with me, and has not been as yet generally accepted. It is caused by the vibrations of the mitral curtains, and takes place when these curtains are united at their sides, leaving a narrow buttonhole-like orifice through which the

mitral direct current of blood flows. Throwing the lips into vibration with the breath, represents not only the characteristic quality of the murmur, but the mode of its production. The physical conditions which are requisite generally for its production are a narrowed mitral orifice, and flaccidity of the mitral curtains. The latter of these conditions does not always exist in cases of mitral obstructive lesions, and, hence, the murmur by no means always accompanies these lesions. When it is considered how loud a blubbering sound may be produced by the vibration of the lips with a feeble current of air, it is not difficult to understand that an intense murmur may be caused by a current of blood propelled by the comparatively weak contraction of the auricle. This murmur may be produced artificially, and the mechanism of its production demonstrated in the following manner: Take a small India-rubber bag with thin walls—such as that which, when inflated, makes a balloon for children; attach the opening to the efferent tube of a Davidson's syringe; make a small orifice opposite to the attached opening of the bag; immerse the bag in a basin of water, and then force a current of water into the bag. With a binaural stethoscope, the pectoral extremity applied lightly to the bag, a murmur caused by the flow of water from the bag into the basin, is heard, resembling as closely as possible the usual presystolic murmur.

A mitral direct murmur may be produced without mitral lesions, the murmur having the same characteristic quality as when lesions exist, and being

also quite loud. This fact, based on clincial proof, was stated by me many years since, together with the explanation. The murmur occurs when there are aortic lesions which permit regurgitation. Under these circumstances, at the time when the auricular contraction takes place, the left ventricle is already filled with blood, the mitral curtains are floated out so as to be in contact with each other, and the mitral direct current passing between the curtains throws them into vibration precisely as when the orifice is narrowed. The vibration of the lips when lightly in contact, caused by the expired breath, illustrates the manner in which a mitral direct murmur takes place without mitral lesions. The murmur thus occurring without mitral lesions is not constant; it is now present and now absent, depending, as it does, on the quantity of blood within the left ventricle at the time of the contraction of the auricle. It follows from what has just been stated, that a mitral direct murmur is not always a sign of mitral obstructive lesions when there is free aortic regurgitation. (This murmur is commonly recognized in the United States as the Flint murmur.)

This murmur is limited to a circumscribed space around the apex of the heart. However loud the murmur may be in this situation, it is usually lost within a short distance of the apex, although in rare instances it may be heard over the lower part of the left scapula.[1]

[1] For further diagnostic and explanatory details of the Flint murmur the reader is referred to an article by Thayer in Amer. Jour. Med. Sci., 1901, cxxii, No. 6.

A mitral direct murmur is never due to a morbid condition of the blood. Although it occurs without mitral lesions, yet, inasmuch as its occurrence then requires the existence of aortic regurgitant lesions, it cannot be said to be an inorganic murmur. A mitral direct murmur may occur in adherent pericardium (chronic fibrous pericarditis), and in large hearts without valvular lesions; in the latter the accessory signs of mitral stenosis are lacking.

A mitral direct murmur, as has been stated, does not always accompany mitral lesions. If the mitral curtains are fixed or made rigid by calcification, so that vibration with the mitral direct current of blood does not take place, either the murmur is wanting, or its usual characteristic quality is absent. Feebleness of the auricular contraction, from dilatation or overdistention of the auricle with blood, may cause the murmur to disappear. Under these circumstances the murmur may be sometimes present and at other times absent. Cardiac vibration or thrill is a physical sign which accompanies often a well-marked characteristic presystolic murmur, but this sign may occur in connection with other valvular lesions. The thrill is presystolic in time when it accompanies the presystolic murmur. The thrill is systolic when it accompanies an aortic direct or a mitral regurgitant murmur, and diastolic when it accompanies an aortic regurgitant murmur.

Mitral Diastolic Murmur.—A murmur may be produced by the mitral direct current of blood prior to the contraction of the left auricle; in other words,

occurring before the presystolic murmur. From the latter this murmur may be distinguished as a mitral diastolic murmur. The flow of blood from the auricle into the ventricle begins directly the ventricular systole ends. This may be said to be a passive current until the auricle contracts. The contraction of the auricle makes the current active. Now, under certain organic conditions, the passive current produces a murmur which, in point of time, is diastolic, that is, directly following the diastolic sounds of the heart. The murmur occurs at the same time as an aortic regurgitant murmur. From the latter it is to be discriminated by its localization at or near the apex of the heart, and by the absence of a diastolic murmur at the base. It may precede the characteristic presystolic murmur, differing from the latter in quality; or the diastolic murmur, without the characteristics which usually belong to the presystolic murmur, may continue during the whole of the long pause of the heart.

The mitral diastolic murmur (as this murmur may be called) is doubtless rare, but less so, perhaps, than may be supposed, for two reasons: (1) It is apt to be overlooked; and (2) when recognized it has been customary to refer it to the aortic orifice. The frequency of the murmur and the particular physical conditions under which it is present are to be determined by further clinical study. It is apparent that in mitral stenosis owing to the differences in the size of the opening, the flexibility of the cusps, the volume of blood and the force of the auricular contraction

we may have an absence of any murmur, or most commonly a presystolic murmur, or less often a murmur which may occupy any point of time between the systolic sound and the diastolic sound of the heart, *i. e.*, a diastolic, or meso-diastolic, or diastolic-presystolic murmur.

Mitral Regurgitant Murmur — Mitral Systolic Non-regurgitant, or Intra-ventricular Murmur.—The mitral regurgitant murmur, synchronous with the systolic sounds, that is, a systolic murmur, may be soft, rough, or musical in quality, its intensity and pitch being variable. Aside from its relation with the systolic heart-sounds, it is distinguished by having its maximum of intensity at or near the situation of the apex-beat. It may be limited to a circumscribed area, and if heard at a distance from the apex it is best transmitted laterally round the left side of the chest, on the line of the apex. It is often heard on the posterior aspect of the chest near the lower angle of the left scapula, and not infrequently in the corresponding situation on the right side.

A murmur with the systolic sounds of the heart, heard within a limited area at the apex, may be due to roughness of the endocardial membrane without mitral incompetency, and, consequently, without a mitral regurgitant current. This is a mitral systolic non-regurgitant murmur. It may, also, be called an intra-ventricular murmur, being produced, not at the mitral orifice, but within the ventricle. This murmur cannot always be discriminated from a feeble mitral regurgitant murmur. If, however, a

mitral murmur be conducted laterally for some distance to the left of the apex, and if it be heard on the back, it probably denotes mitral regurgitation. A mitral systolic, non-regurgitant, or intra-ventricular murmur is the murmur present in endocarditis. It may be caused by a tendinous cord extending from the inner wall on one side to the opposite side of the ventricular cavity. This occurs as a congenital anomaly. Aneurism of the heart may be so situated as to give rise to a murmur simulating a mitral systolic murmur. Cardiac aneurysm, however, is exceedingly rare. Aneurysm of the thoracic aorta may cause a murmur which, transmitted through the heart, simulates a mitral systolic murmur.

The impulse of the apex of the heart against the adjacent portion of the lung sometimes forces the air from the air-vesicles sufficiently to give rise to a blowing sound occurring with each ventricular systole. This is liable to be confounded with an endocardial murmur. Produced in the way just stated, it is heard only during the act of inspiration, and especially at the end of this act.

A mitral systolic murmur is rarely, if ever, due to an abnormal condition of the blood, without any anatomical change in the orifice or endocardial membrane. Conditions of the blood, however, which are favorable for the production of inorganic murmurs may intensify this murmur, as well as any of the organic murmurs.

It has been conjectured that a mitral systolic murmur may be produced by a purely functional

incompetency of the mitral valve, permitting a mitral regurgitant current, no actual lesion of the valve or the mitral orifice existing. In this way are explained the occurrence of a mitral systolic murmur and its disappearance without other evidence of endocarditis or any organic affection of the heart. It does not enter into the scope of this work to discuss the validity of this explanation. The fact, however, that a mitral systolic murmur may exist, continue for weeks or months, and even for years, and disappear, the murmur being neither accompanied nor followed by signs or symptoms denoting organic disease, is an important fact to be borne in mind with reference to diagnosis and prognosis. It is apparent from experimental studies as well as from clinical observation that a true mitral regurgitation, with the characteristic murmur so constantly associated when the valve cusps are diseased, may occur from any of several causes which permit of a relaxation of the constrictor ring of muscle which encircles the mitral orifice. Among the causes frequently recognized are, high temperature, acute endocarditis, with or without coexisting chorea, and any cause, either general (anemia) or local (myocarditis), which may interfere with the muscular competence of the mitral ring. Strain of the heart muscle is apt to be a determining factor. Mitral incompetence from such lack of muscular efficiency is much more commonly accompanied by tricuspid incompetence than when the mitral leak is due to disease of the cusps themselves.

Aortic Direct Murmur.—This murmur, like the mitral systolic murmur, occurs with the systolic sounds of the heart. Of the organic murmurs on the left side of the heart, the mitral systolic murmur and the aortic direct murmur are synchronous, the others having different relations with the heart-sounds. The aortic direct murmur differs from the mitral systolic murmur in having its maximum of intensity at the base of the heart. It is loudest in the second intercostal space near the sternum. As a rule, it is louder in this intercostal space on the right than on the left side; this rule, however, has frequent exceptions. It is transmitted better and farther, upward than downward. It is always heard over the carotid artery, and it is sometimes louder over this artery than at the base of the heart. As a murmur may be produced within the carotid artery, it is desirable to determine, when a systolic murmur is heard at the base, whether the carotid murmur is a transmitted murmur or not. This point is to be settled by comparing the murmur over the carotid with the murmur at the base, as regards quality and pitch. If the quality and pitch of the murmur in the two situations be the same, it is fair to consider the murmur in the carotid as not produced within the artery, but conducted by the blood-current from the aortic orifice.

An aortic direct murmur is frequently inorganic. It is to be considered as such when it is not associated with an aortic regurgitant murmur; when the heart is not enlarged; when anemia is shown by the presence of murmurs in the large arteries; and when

there is the venous hum[1] in the neck—these physical evidences of anemia being associated generally, not invariably, with pallor, and with symptoms pointing to impoverishment of the blood. Moreover, an inorganic murmur is very rarely rough, and it is variable in its occurrence, being at one time present and at another time absent, whereas, an organic murmur is, in general, constant. Associated with other evidence of anemia, an aortic direct murmur may, nevertheless, be organic, but, under the differentiating circumstances just stated, the lesion represented by the murmur, if the murmur be organic, must be innocuous, so that it is not of great practical importance to determine whether the murmur be or be not inorganic.

Like the other organic murmurs, an aortic direct murmur varies in different cases in intensity, quality, and pitch. An organic aortic direct murmur, *per se,*

[1] To obtain the venous hum (*bruit de diable*), cause the patient to turn the head as far as practicable to the left, and apply the stethoscope to the neck on the right side, near the clavicle, behind the sterno-cleido-mastoid muscle. Press the stethoscope with different degrees of force before concluding that the murmur is wanting. The venous hum is continuous, and closely resembles the sound of the humming top. Gentle pressure, with the finger above the stethoscope, so as to interrupt the flow of blood in the veins, causes the murmur at once to cease. This fact is proof of its being a venous murmur. A systolic murmur heard with the stethoscope applied to the neck, is an arterial murmur, which may either be produced within the artery, or transmitted from the aortic orifice. An arterial and a venous murmur in the neck often coexist. One cause of error in determining the presence of a true venous hum is the common occurrence of a murmur in the vessels of the thyroid gland.

does not denote always aortic obstruction. It may be due simply to roughness of the membrane at or above the aortic orifice, or to dilatation of the aorta. Such evidence as these, whether attributed to roughness or to dilatation, are recognized as proof of inflammation of the aorta, almost without excep ion of syphilitic origin.

Aortic Regurgitant Murmur—Aortic Diastolic Non-regurgitant Murmur, or a Prediastolic Murmur.—An aortic regurgitant murmur occurs with the second, diastolic, sound of the heart. It is almost always heard at the base of the heart, but, in some instances, when not appreciable at the base, it is heard a little below the base—namely, near the sternum on the left side on a level with the fourth costal cartilage. In some instances, however, the maximum of intensity is in a corresponding situation on the right side. In the latter situation it has generally its maximum of intensity. It is transmitted best in a downward direction, being often heard at the apex, and sometimes considerably outside or external to this point (*i. e.*, in the left axilla). It is never inorganic. It is usually not intense, low in pitch, and soft; but it may be loud, high, rough, or musical.

The aortic diastolic murmur is sometimes heard better with the ear than through a stethoscope.

A short murmur is sometimes produced by the retrograde movement of the blood-current within the aorta, the aortic valve being intact, and regurgitation, therefore, not taking place. This murmur is due to roughening of the lining membrane of the

aorta by atheroma or calcareous deposit, and it is always preceded by an aortic direct murmur. It occurs directly after the systole, and ends with the second sound. Although of such brief duration, it is distinctly recognizable and distinguished from the preceding aortic direct murmur. I have long been accustomed to demonstrate this murmur in private teaching, and have called it an aortic diastolic non-regurgitant murmur. A better name is a prediastolic murmur. It cannot be said to have much practical importance, inasmuch as the lesion giving rise to it is represented by the aortic direct murmur which precedes it. This murmur may be associated with a true regurgitant murmur. This is the explanation of a diastolic murmur which is rough before and soft after the aortic second sound.

Coexisting Endocardial Murmurs.—The murmurs referable to the left side of the heart, which have been considered, are often found in combination; two or three may coexist, or all of them may be present. Moreover, with more or less of these murmurs may be associated murmurs referable to the right side of the heart. Having become familiar with their relations with the heart-sounds, and other points involved in their differentiation, it is not difficult to recognize them in combination. The mitral murmurs are not infrequently associated. The mitral direct, being presystolic, ends with the systolic sounds, and the mitral systolic or regurgitant begins with these sounds; the systolic sounds, as it were, divide these two murmurs. These murmurs almost invariably differ from each other in pitch and

quality. The presence of both, in fact, assists, rather than obstructs, the recognition of each. The aortic direct and the aortic regurgitant murmur, also, are often associated. A murmur then accompanies the systolic and the diastolic sounds of the heart; the two murmurs follow in the same rhythmical order as the groups of heart-sounds. These murmurs, when associated, can only be confounded with pericardial friction-sounds.

The combination of the aortic direct and the mitral systolic murmur, alone offers any difficulty. These two murmurs have the same relation with the heart-sounds; they are both systolic. How is it to be determined, when a systolic murmur is heard both at the base and apex, whether a mitral murmur is transmitted to the base, or an aortic murmur is transmitted to the apex; in other words, how is it to be decided whether two murmurs are present or only one murmur? If these two murmurs coexist, generally the circumstances which distinguish each separately can be ascertained. Thus, the aortic murmur is transmitted into the carotid artery, and the presence of that murmur is then established; the mitral regurgitant murmur is often transmitted laterally around the chest, or heard at the lower angle of the scapula, and then the presence of that murmur is established. But there are additional points, namely, the murmur at the base, and that at the apex generally differ sufficiently in pitch or quality to render it evident that there are two murmurs; and generally at a situation in the precordia between the base and apex, both murmurs

may be either lost or become notably weakened. Attention to these points in most instances divests the problem of difficulty.

Mitral and aortic lesions are often of a character to give rise to only one murmur at either of these orifices. A mitral direct murmur not infrequently is present without the mitral regurgitant, and the reverse of this is often found. So, either an aortic direct or an aortic regurgitant murmur may exist without the other.

Tricuspid Direct Murmur.—The lesions which are requisite for this murmur very rarely occur at the tricuspid orifice; hence, this murmur is exceedingly rare. It is to be distinguished from the mitral direct murmur by its localization being, not at the apex, but at the right border of the heart. Mitral direct murmur is usually found to coexist with a tricuspid direct murmur, in which case a presystolic murmur, with the characteristic blubbering quality is heard at the apex and at the right side of the heart.

Tricuspid Regurgitant Murmur.—This murmur is not of infrequent occurrence. Tricuspid regurgitation occurs often when the right ventricle is considerably dilated, without the existence of lesions of the valve. A tricuspid regurgitation current, however, does not invariably give rise to an appreciable murmur. When a ventricular venous pulse is found in the neck, or better still, if a systolic liver pulse is found, these help materially to establish a diagnosis of tricuspid regurgitation, when taken with the other signs.

The tricuspid regurgitant murmur, of course, occurs

with the first or systolic sound, being systolic like the mitral regurgitant murmur, and the latter generally coexists. It is distinguished from the mitral regurgitant by its localization at the right inferior margin of the heart, and its transmission to the right, rather than to the left. The coexistence of the mitral and the tricuspid regurgitant murmurs is determined by the differences in pitch and quality, between a systolic murmur at the apex, and at the right margin of the heart. A venous pulse, synchronous with the first sound of the heart, points to tricuspid regurgitation, and, although sometimes present without a tricuspid regurgitant murmur, when present, it is corroborative evidence of the latter.

Pulmonic Direct Murmur.—A pulmonic direct murmur, if organic, is generally connected with congenital lesions. The pulmonic direct and the aortic direct current of blood taking place at the same instant, the murmurs representing both are, of course, systolic. How is the pulmonic to be distinguished from the aortic direct murmur? The pulmonic murmur is heard in the left second intercostal space close to the sternum, but this is not very distinctive, inasmuch as, not infrequently, the aortic murmur is loudest in that situation. The essential point of distinction is this: the pulmonic direct murmur is not transmitted into the carotid artery, whereas, the aortic direct murmur is always thus transmitted. A systolic thrill, appreciated by firm palpation in the second left interspace, is an important and fairly constant sign in pulmonary stenosis. If an aortic direct and a pulmonic

direct murmur coexist, both being organic, the combination is to be ascertained by finding that the murmur in the second intercostal space on the right side differs from that on the left side in pitch or quality, sufficiently to show the presence of these murmurs, the one on the right side being transmitted to the carotid artery.

An inorganic, or functional, pulmonic direct murmur is of frequent occurrence in cases of anemia. It is frequently associated with an inorganic aortic direct murmur, the presence of the two murmurs being evidenced by a difference in pitch.

Pulmonic Regurgitant Murmur.—This murmur is exceedingly rare in consequence of the infrequency of pulmonic regurgitant lesions. It occurs, of course, like the aortic regurgitant, with the second or diastolic sound. Its presence can be determined, when other signs go to show the existence of pulmonic, and the absence of aortic lesions. This murmur may, however, occur without any lesion or deformity of the pulmonary valve cusps or of its orifice, under conditions similar to those which may determine an aortic regurgitant murmur—namely, such a state of increased blood pressure in the pulmonary artery, due to marked obstruction in the pulmonary vessels, as will cause a dilatation of the pulmonary orifice, and lack of apposition of the semilunar cusps. This so-called murmur of high pressure in the pulmonary artery is commonly known as the Graham-Steell murmur. A pulmonic regurgitant murmur may occur from pressure upon the pulmonary artery from without.

Facts of practical importance in relation to the endocardial murmurs, are embraced in the following statements:

The question as to a murmur being organic or inorganic, relates chiefly, if not entirely, to the aortic direct, the pulmonic direct, and the mitral regurgitant murmur, other murmurs being almost invariably organic.

Associated signs and symptoms generally warrant a definite conclusion whether an aortic direct or pulmonic direct murmur be, or be not, organic, and under the circumstances which render it difficult to decide this question positively, a positive decision is not of much immediate practical consequence.

Valvular lesions, whether obstructive, regurgitant, or innocuous, are so uniformly represented by murmur, in a compensating heart, that, as a rule, absence of lesions may be predicated on the absence of murmur. If, however, the signs and symptoms of a decompensating heart are present, no conclusions should be drawn, from the presence or absence of murmurs, as to the existence or location of valvular lesions.

With a practical knowledge of the different organic murmurs, the situation of lesions at either of the orifices of the heart, or their existence at two or more of these orifices, may be demonstratively determined.

By means of the murmurs, with other signs, it may be determined demonstratively whether the lesions involve obstruction or regurgitation, or both, or, on the other hand, that they are, as regards immediate pathological effects, innocuous.

The murmurs do not afford definite information

as to the amount of obstruction or regurgitation, in other words, as to the pathological importance or gravity of lesions when they are not innocuous. No positive conclusions on this point of view are to be drawn from the intensity of murmurs, their pitch, or their quality. As a rule, murmurs which are weak, more than those which are loud, represent grave lesions.

Pericardial or Friction Murmur.—A pericardial or friction murmur is produced by the rubbing together of the surfaces of the pericardium in the systolic and diastolic movements of the heart. In the vast majority of the cases in which this murmur occurs, it denotes either the presence of recent lymph which renders the surfaces more or less adhesive, or roughening from lymph which has become dense and adherent; its diagnostic significance, therefore, relates almost exclusively to pericarditis. In this relation it is of great practical importance.

This exocardial murmur is to be discriminated from the endocardial murmurs. The points involved in the discrimination are as follows: The murmur is double, that is, a murmur accompanies both the ventricular systole and diastole. It can, therefore, only be confounded with an aortic direct and an aortic regurgitant murmur in combination. The quality of the murmur is suggestive of rubbing or friction. It is sometimes a feeble, grazing sound; in other instances it is loud and rough. When rough, the quality is expressed by such terms as rasping, grating, creaking, etc. Although accompanying both the systolic and diastolic sounds of the

heart, it has not that uniform, fixed relation to these sounds which characterizes the aortic direct and the aortic regurgitant murmur; it is not in definite accord with the heart-sounds. Moreover, in intensity it varies with the successive movements of the heart, being louder with some revolutions than with others, in this regard differing notably from the endocardial murmurs. It is not heard without the precordia, as a rule, and is often limited to a part of the precordial region, whereas, certain of the endocardial murmurs namely—the mitral regurgitant and the aortic direct—are often heard at a considerable distance from the heart. Firm pressure with the stethoscope, and often a forced expiration, intensify the murmur. Its source seems very near the surface of the chest. In this respect it differs notably from endocardial murmurs, the latter appearing to come from a certain distance within the chest. This point of distinction is very appreciable, especially if, as often happens, a friction murmur be associated with an endocardial murmur.

CHAPTER VIII

THE PHYSICAL DIAGNOSIS OF DISEASES OF THE HEART AND OF THORACIC ANEURISM

Enlargement of the heart by hypertrophy and dilatation—Valvular lesions, mitral, aortic, tricuspid, and pulmonic—Diseases of the heart muscle—Endocarditis—Pericarditis—Functional disorders—Congenital defects—Thoracic aneurism.

The morbid physical conditions incident to the different diseases of the heart, and the signs representing these conditions, have been considered in the preceding chapter. The diseases are now to be considered with reference to the assemblage of signs on which the physical diagnosis of each is to be based. Most of the diseases of the heart may be diagnosticated by means of physical signs. A few cardiac lesions do not admit of a physical diagnosis, and they do not, therefore, claim consideration in this work. The following are the affections which will form separate headings in this chapter: Enlargement of the Heart by Hypertrophy and by Dilatation, Valvular Lesions, Diseases of the Heart Muscle, Endocarditis, Pericarditis, Functional Disorders, and Congenital Defects. Having considered these affections, the physical diagnosis of thoracic aneurism will be the concluding topic.

Enlargement of the Heart by Hypertrophy and by Dilatation.—Physical exploration to determine the size of the heart has three objects—namely, to determine (1) that the size of the heart is normal, or (2) that the heart is enlarged, and (3) the degree of enlargement. These objects are attainable by means of percussion and auscultation, with considerable accuracy, but for truly precise delimitation of the heart the orthodiagraphic method with the *x*-ray is preferable.

The heart is of normal size when the apex-beat is in its normal situation, that is, in the fifth intercostal space, a little within the mid-clavicular line. When the superficial cardiac space is not enlarged, as shown by percussion and by auscultation of the voice (*vide* page 227), and when percussion shows the lateral borders of the heart to be situated normally—namely, on the left side a little within the line of the nipple, and on the right side a finger's breadth to the right of the right margin of the sternum—these points of evidence warrant a positive conclusion that the heart is not enlarged, if the lung borders overlapping the heart are normal.

The fact of an enlargement, and its degree, are determinable by an abnormal situation of the apex, together with an increase of the superficial cardiac space, and extension of the lateral boundaries of the deep cardiac space, especially on the left side.

In cases of slight or very moderate enlargement, the apex is situated a little without the mid-clavicular line, but not below the fifth intercostal space. A somewhat greater enlargement lowers the apex to the sixth intercostal space, and removes it farther

without the mid-clavicular line. In greater degrees of enlargement the apex is lowered to the seventh, eighth, or ninth intercostal space, and generally farther removed to the left. The lowering of the apex and the removal to the left are not uniformly proportionate to each other. As a rule, if the right side of the heart be more enlarged than the left, the apex is removed without the mid-clavicular line farther than when the enlargement of the left side of the heart predominates, and when the latter is the case, the apex is lowered out of proportion to its removal without that line. The relatively abnormal situation downward or to the left, thus, is evidence of the enlargement predominating in either the left or the right side of the heart. Generally the situation of the apex is apparent to the touch, and frequently to the eye. In some instances, however, the impulse can neither be seen nor felt. How is its situation to be then ascertained? Auscultation furnishes a ready and reliable mode of determining this point. The situation in which the first sound of the heart has its maximum of intensity, as ascertained by means of the stethoscope, corresponds to the situation of the apex. This is hardly less definite than the presence of an appreciable impulse.

In determining the fact of enlargement and its degree by the abnormal situation of the apex, causes of the latter which are extrinsic to the heart are to be eliminated. The apex is removed to the left of its normal situation by enlargement of the left lobe of the liver, abdominal tumors, hydroperitoneum,

the pregnant uterus, and gastric tympanites. These extrinsic conditions are to be excluded or due allowance made for them. In some cases in which one or more of these extrinsic causes of displacement may exist the apex is carried into the axillary region. It is to be borne in mind that these causes of displacement may exist when there is more or less enlargement of the heart. All these causes, while they displace the apex to the left, do not lower, but tend to raise it above its normal situation. On the other hand, an aneurismal or other tumor, situated above the heart, may press downward the organ, or an unusually long first portion of the arch of the aorta may occur, and in this way the apex is more or less lowered.

The superficial space is increased in proportion as the heart is enlarged. The extent of this increase is easily determined by percussion and auscultation. Within this space there is notable dulness on percussion. The degree of dulness is greater than within the superficial cardiac space in health, and this degree of dulness is proportionate to the greater area in which the heart is uncovered of lung. It is easy to delineate by percussion on the chest the boundary of the anterior border of the upper lobe of the left lung, in other words, of the oblique line which is the hypotenuse of the right-angled triangle, representing the superficial cardiac space in health, and in disease. The area of the superficial cardiac space is also not less readily and precisely ascertained by auscultation of the voice; the limits of the lung within the precordia are denoted by an abrupt cessation or notable diminution of the vocal resonance.

In women with large mammæ auscultation is more available for this object than percussion. The extent to which the superficial cardiac space is enlarged, is a good criterion of the degree of the enlargement of the heart.

In proportion as the heart is enlarged, the situation of the left border is without the mid-clavicular line. Its situation is determined by percussion. Dulness, although not great, is sufficiently distinct within the deep cardiac space, and the line which denotes the left border of the heart is easily delineated on the chest. This statement holds true with respect to the right border of the heart, but this border, even when the enlargement of the heart is great, is removed comparatively little to the right of its normal situation, except in dilatation of the right auricle and right ventricle in tricuspid regurgitation, when it is not unusual to find the superficial cardiac dulness as much as three finger's breadths to the right of the sternum in the third and fourth interspaces. By means of percussion, the boundaries of the precordia, as enlarged by the increased size of the heart, may be determined and measured. In making this statement, it is assumed that the lungs are not diseased, and that the chest is not deformed. Shrinkage of the upper lobe of the left lung may enlarge the superficial cardiac space, and cause displacement of the heart. The latter is an effect of the presence of pleuritic effusion, and it may follow its removal. In cases of deformity from spinal curvature, to determine the fact of enlargement of the heart, or its degree, is not always an easy problem.

There is a liability to error in localizing the apex in some cases of enlargement. Owing to the blunted form of the apex, especially when the enlargement is chiefly of the right side of the heart, the apex-beat may be feeble. It is likely to be overlooked, and a stronger impulse in the intercostal space above the apex be mistaken for the apex-beat. Of course, the lowest impulse is the apex-beat. Careful palpation, and finding by auscultation the spot where the first sound has its maximum of intensity, will prevent this error.

Enlargement of the heart, and the degree of enlargement having been ascertained, it is to be determined whether hypertrophy or dilatation predominate. If the enlargement be slight or moderate, it may be a question whether hypertrophy or dilatation exist alone. As a rule, if either of these two forms of enlargement exist without the other, it is hypertrophy, for, with rare exceptions, hypertrophy precedes dilatation. If the enlargement be very great, as a rule, dilatation predominates, for the capability of hypertrophic increase of size has its limit, and an increase of size beyond this limit must be due to dilatation.

The signs, denoting on the one hand hypertrophy, and on the other hand dilatation, relate to the impulses of the heart and to the heart-sounds. With a moderate enlargement, hypertrophy is to be inferred from an abnormal force of the apex-beat, and an intensification of the systolic sounds, especially the sound of impulsion over the apex. With a considerable or great enlargement, if hypertrophy predominate,

the apex-beat may be abnormally strong and prolonged, but, as already stated, owing to its blunted form, the beat is sometimes weak and scarcely appreciable; the increased power of the ventricular contractions, representing the hypertrophy, is then to be determined by impulses in the intercostal spaces above the apex. These impulses are sometimes present in each intercostal space between the apex and the base, and they are abnormally strong in proportion as hypertrophy predominates. Still more marked evidence of hypertrophy is sometimes obtained when the hand is placed over the precordia; a powerful heaving movement is felt. The increased power of the ventricular contractions may, in some cases, be in this way appreciated somewhat as if the heart were held in the hand. In cases of considerable or great hypertrophic enlargement, the intensity of the sound of impulsion over the apex is notably increased; it is prolonged, and its booming quality is more marked than in health. Not infrequently it is accompanied by a metallic ringing sound or tinnitus.

Moderate enlargement by dilatation is characterized by abnormal weakness of the apex-beat, and of the systolic sounds over the apex. Cases, however, of simple dilatation are rare. If the enlargement be considerable or great, and dilatation predominate, all the impulses are weak, as compared with the cases in which hypertrophy predominates, and the sound of impulsion over the apex is diminished or nil, the feeble, short, mitral valvular sound either supplanting, or predominating over the sound of impulsion. These

points of distinction are marked in proportion as dilatation predominates.

In the great majority of the cases of enlargement of the heart, valvular lesions coexist. These coexisting valvular lesions are represented by endocardial murmurs, and they may generally be excluded by the absence of the latter. In most of the cases in which enlargement exists without valvular lesions, it is associated with either pulmonary emphysema or chronic Bright's disease.

VALVULAR LESIONS

The physical diagnosis of valvular lesions embraces their localization at the different orifices within the heart, and the determination of their character as giving rise to obstruction and regurgitation, or of their innocuousness in these respects. These objects of diagnosis involve the endocardial murmurs and the abnormal modifications of the heart-sounds which were considered in the preceding chapter. Lesions at the different orifices—namely, the mitral, aortic, tricuspid, and pulmonic—will be considered separately.

Mitral Lesions.—The lesions at the mitral orifice are represented by the mitral murmurs—the mitral direct murmur, the mitral regurgitant, the mitral systolic non-regurgitant or intra-ventricular, and the mitral diastolic murmur. Mitral obstructive lesions exist whenever the mitral direct murmur is present,

with an exception already stated and explained (*vide* p. 263)—namely, this murmur is present in some cases in which the mitral valve is intact, aortic lesions, giving rise to free regurgitation, existing in these cases. These exceptional instances are rare.

Mitral regurgitant lesions exist whenever a mitral murmur which is truly regurgitant is present. A systolic murmur having its maximum of intensity at or near the apex, transmitted laterally for a certain distance beyond the apex on the left side of the chest, and heard on the back near the lower angle of the scapula, generally, if not invariably, denotes a regurgitant current; but a systolic murmur limited to a small area around the apex, or to the superficial cardiac space, is not proof of regurgitation. A truly regurgitant murmur, however, may be too feeble to be transmitted beyond the apex; the proof of regurgitation must then be based on other evidence associated with the murmur—namely, on enlargement of the heart and abnormal modifications of the heart-sounds.

Mitral obstruction may exist without incompetency of the mitral valve, as shown by the presence not very infrequently of a mitral direct, without a mitral regurgitant murmur. The converse of this is of more frequent occurrence, that is, regurgitation may exist without obstruction. The absence, however, of a mitral direct murmur is not positive proof against mitral lesions, for, as has been seen, the production of a characteristic mitral direct murmur requires the obstruction to be caused by an adherence of the

mitral curtains at their sides, the curtains being sufficiently flexible to vibrate with the passage of the mitral direct current of blood. If these conditions for the production of the murmur do not exist, there may be no murmur produced by the mitral direct current, or, if a murmur be present, it is devoid of the usual characteristic quality. Mitral obstruction and regurgitation not infrequently coexist, as shown by the presence of both the mitral direct and the mitral regurgitant murmur. A mitral murmur, produced by a mitral direct current, but diastolic in point of time, is sometimes, as has been seen (*vide* page 265), observed in connection with mitral lesions. It is accepted now, on accurate experimental and clinical evidence, that the cause of the change in time of the mitral direct murmur, from presystolic to mid-diastolic, is the development or onset of fibrillation of the auricle. This results in a loss of the presystolic propulsive force, which determines the incidence of the usual presystolic mitral murmur, as long as the auricle contracts effectively.

The mitral murmurs do not, *per se,* denote the amount of obstruction or regurgitation, or of both combined. Information with reference to these points may be derived, in the first place, from a comparison of the aortic with the pulmonic second sound. The amount of obstruction or regurgitation, or both, is great in proportion as the aortic sound is weakened, or the pulmonary sound accentuated, or both. *Per contra,* there can be but little obstruction or regurgitation, if the aortic and the pulmonic second sound

preserve completely or nearly their normal relation to each other in respect of intensity. Information may, in the second place, be obtained by directing attention to the mitral valvular sound (*vide* page 235). In proportion as the function of the mitral valve is compromised by lesions, the mitral valvular sound at the apex will be weakened. In some cases this sound is lost, the sound of impulsion remaining.

Enlargement of the right side of the heart, which results from mitral obstructive and regurgitant lesions, is a criterion of the amount of obstruction and regurgitation, taken in connection with the length of time they have existed. Hypertrophic enlargement of the right ventricle intensifies the pulmonic second sound, and allowance must be made for this modification in determining, by a comparison of the pulmonic and the aortic sound, the degree in which the latter is weakened. Attention is to be given to the tricuspid valvular sound (*vide* page 235). The intensity of this sound is, in some measure, a criterion of the power of the right ventricular systole.

Aortic Lesions.—Lesions are localized at the aortic orifice by the aortic murmurs—namely, the aortic direct and the aortic regurgitant murmur. Aortic obstructive lesions give rise to an aortic direct murmur; but it must be considered, in the first place, that an aortic direct murmur may be inorganic, and, in the second place, that if the murmur be organic it may be produced by lesions which occasion no obstruction, and are consequently innocuous. The existence of obstructive lesions must be determined

by evidence added to the presence of the murmur. This evidence is either diminished intensity or suppresssion of the aortic second sound, and enlargement of the left ventricle. If the lesions which occasion obstruction are of a character to diminish or arrest the movements of the aortic valve, the aortic second sound will be either weakened or lost. If valvular lesions be limited to the aortic orifice, the degree of enlargement of the left ventricle is a criterion of their pathological importance.

Regurgitant lesions at the aortic orifice give rise to an aortic regurgitant murmur. This murmur, of course, is always proof of regurgitation; but the murmur gives no definite information concerning the amount of incompetency of the aortic valve. A loud murmur may be produced by a regurgitant stream so small as to be, for the time, insignificant; and, on the other hand, a large regurgitant current may give rise to a feeble murmur. The extent to which the valve is damaged by the lesions is to be determined, first, by either weakness or suppression of the aortic sound, and, second, by the degree of enlargement of the left ventricle.

Aortic obstructive and regurgitant lesions are often associated. An aortic direct and an aortic regurgitant murmur are then both present, with a weakened aortic sound or its suppression, and enlargement of the left ventricle according to the amount of the obstruction and regurgitation, together with the length of time during which the latter have existed. These effects, and not the intensity, nor the pitch,

nor the quality of the murmurs, are indicative of their pathological importance.

Mitral and aortic lesions often coexist, giving rise to two, three, or four of the obstructive and regurgitant murmurs in the left side of the heart. In addition to the murmurs in these cases, the effects of the combined lesions are shown in the modification of the heart-sounds, and the enlargement of both sides of the heart.

Tricuspid Lesions.—Tricuspid obstructive lesions are exceedingly rare. A few instances of the kind of obstruction which is represented by a tricuspid direct or presystolic murmur, have been reported. One instance has fallen under my observation. In this case, as in the other instances which have been reported, the tricuspid was associated with mitral lesions; hence, in localizing an obstructive lesion at the tricuspid orifice, the presence of the presystolic murmur on each side of the heart, that is, the coexistence of the mitral and the tricuspid direct murmur is to be determined. This point has already been considered (*vide* page 275). Signs which are accepted as fairly characteristic of tricuspid stenosis are: a presystolic murmur at the tricuspid area without accentuation of the second pulmonic sound; often in addition an aortic lesion; an enlarged right ventricle and auricle, distended veins in the neck, frequently without pulsation; persistent cyanosis of mucous membranes and skin, and marked tendency to edema or general anasarca with relatively little dyspnea. The diagnosis should be made without a presystolic murmur, as this is

inconstant. There is almost always coincident mitral stenosis. There is likely to be a pulsation recorded over the liver coincident with auricular contraction.

Tricuspid regurgitation is not uncommon. Generally the insufficiency is caused by dilatation of the right ventricle occurring as an effect of mitral regurgitant or obstructive lesions. Tricuspid regurgitation is not always represented by murmur; and when a tricuspid regurgitant murmur is present, it is to be discriminated from a coexisting mitral regurgitant murmur. This point has been considered (*vide* page 275). A sign of free tricuspid regurgitation with hypertrophy of the right ventricle, is pulsation of the liver, which may be seen and felt, and is synchronous with ventricular systole. This pulsation is sometimes notably strong. If the liver be enlarged, the pulsation may be communicated to the greater part of the abdomen, and its force may be suggestive of aneurism of the abdominal aorta. Pulsation of the liver may be observed when there is no ventricular jugular pulse, nor notable turgescence of the cervical veins.

Pulmonic Lesions.—As compared with aortic lesions, these are of infrequent occurrence, and they are generally congenital. Lesions giving rise to a pulmonic direct murmur may be localized by differentiating this murmur from the aortic direct murmur (*vide* page 276). It is to be considered that an inorganic pulmonic direct murmur is not infrequent. Pulmonic regurgitant lesions can only be diagnosticated by determining that a murmur is produced at the pulmonic, and not at the aortic orifice (*vide* page 277).

DISEASES OF THE HEART MUSCLE

None of the diseases of the heart muscle is represented by distinctive physical signs, but, nevertheless, the physical diagnosis, taking into account the clinical history, may be quite positive. The signs, as well as the symptoms, are those which denote persistent muscular weakness of the heart. The most marked evidence is notable weakness of the systolic sounds, and especially weakness or suppression of the sound of impulsion. In the acute degeneration of the myocardium which accompanies acute infectious fevers, enfeeblement or disappearance of the apex-beat and weakness of the systolic sounds are the only signs, and the symptoms are only part and parcel of the symptoms of the underlying disease. The same is true of the brown atrophy of the heart which occurs in wasting diseases, such as tuberculosis and cancer.

In the more serious changes of acute infectious myocarditis, as seen in diphtheria, acute articular rheuma ism, some cases of pneumonia and influenza, and rarely in other infections, to these signs may be added the signs of dilatation of the heart, with or without a functional mitral regurgitation. The symptoms of muscular weakness of the heart become prominent, and various disturbances of rhythm may arise from damage to areas of the heart having specialized functions.

Heart muscle weakness is a part of the clinical picture of anemia of any severity. Here some dila-

tation is the rule, the apex-beat is more diffuse, the impulse sudden, the sound of impulsion feeble, the systolic sound valvular in quality. A systolic murmur is heard over the pulmonary artery; also, as a rule, a mitral regurgitant murmur, due to dilatation of the mitral orifice. In the more severe fatty degeneration of the heart of pernicious anemia, similar signs are found, but the enlargement is more marked, hypertrophy and dilatation being usual, and the murmurs are more pronounced. Venous hum in the neck is helpful in the diagnosis of the heart muscle weakness of anemia (*vide* p. 271).

Chronic myocarditis, as a sequel of acute myocarditis, of coronary artery disease with multiple small infarctions (fibroid myocarditis), or primary, as in syphilitic myocarditis, the fatty heart, and other chronic affections of the myocardium, cannot be distinguished from one another with certainty during life. The most that can be attempted wisely is the diagnosis of chronic myocardial disease or weakness, and its discrimination from myocardial weakness secondary to chronic valvular disease, adherent pericardium, the hypertrophy of Bright's disease, emphysema, and so forth. The most important physical sign is the loss of the sound of impulsion at the apex, the systolic sound which is heard being chiefly or exclusively the mitral valvular sound. This sound is short and valvular in quality, like the diastolic sound. The apex-beat may be feeble, or diffuse and shock-like. If the heart be dilated, the apparent force of the apex-beat is in contrast to the feebleness of the radial pulse. With

dilatation, functional mitral, and also tricuspid, regurgitation may occur, and reach such a grade as to render the discrimination from primary mitral valvular disease difficult, if not impossible. The history of past acute articular rheumatism, or a known mitral murmur, is of special importance in making the decision. In muscular weakness a systolic murmur at the apex may be brought out only by exercise. This should always be sought for.

Various disturbances of rhythm may occur, of which the most important are heart-block, due to a lesion involving the atrio-ventricular bundle, and the perpetual irregularity which denotes auricular fibrillation. When the latter exists, it may be difficult or impossible to distinguish primary myocardial disease from mitral obstruction after the disappearance of the mitral direct murmur. Here again the history is of more value than the physical signs.

Endocarditis.—The physical diagnosis of endocarditis relates especially to its occurrence in connection with articular rheumatism. A variety of murmurs may occur, the commonest one, and one upon which the diagnosis is often based, is a mitral systolic but non-regurgitant murmur (*vide* page 267). The presence of this murmur, however, in a case of rheumatism, is not positive proof of an existing endocarditis, more especially if the patient have previously had articular rheumatism, because an endocarditis developed in a previous attack may have left a permanent murmur. If the murmur be a mitral regurgitant murmur, and the heart be enlarged, it is quite certain that endo-

carditis has previously occurred. The positive proof is the production of the murmur during an attack of rheumatism, when previous examination, made after the commencement of the rheumatic attack, had shown that there was no mitral murmur. An aortic direct murmur, in cases of rheumatism, is not evidence of endocarditis, because in many cases of rheumatism this murmur occurs and is to be regarded as inorganic.

In the variety of endocarditis, known as ulcerative, occurring in the course of infectious or septic diseases, and sometimes without any known point of entrance of the infecting organism, an aortic murmur may be developed, with or without a coexisting mitral murmur, owing to the soft masses present on the valves.

Acute endocarditis is probably of frequent occurrence as secondary to mitral and aortic valvular lesions; but, under these circumstances, a physical diagnosis is impracticable.

Pericarditis.—The physical diagnosis of pericarditis in the first stage, that is, prior to the effusion of liquid, is to be based on a pericardial friction murmur. Fortunately for diagnosis, this murmur is uniformly present, though at times for only a brief period. Its characters as contrasted with endocardial murmurs have been stated (*vide* page 279). The presence of a pericardial friction murmur, in connection with symptoms denoting pericarditis, renders the diagnosis quite positive. There is, however, one liability to error. In some cases of pleurisy or pneumonia with pleuritic inflammation, the movements of the heart occasion a rubbing together of the

roughened pleural surfaces, and in this way a cardiac pleural friction murmur is produced (pleuro-pericardial). This may be single or double, and when double, it simulates the murmur produced within the pericardial sac. It is limited to the border of the heart, and is neither accompanied nor followed by pericardial effusion. Of course, the error of mistaking a cardiac pleural friction murmur for one produced within the pericardium, can only occur when pleurisy exists, either as a primary affection or as secondary to pneumonia, or to pulmonary tuberculosis.

In the second stage of pericarditis, that is, after the effusion of liquid has taken place, the pericardial friction murmur often, but not always, disappears. The physical diagnosis in this stage is then to be based on the signs which show the presence of a greater or less quantity of liquid within the pericardial sac. The signs which denote pericardial effusion, and its amount have been stated (*vide* page 241). With a moderate effusion, the apex of the heart is raised, and the apex-beat may be felt in the fourth intercostal space, and removed to the left of its normal situation. With considerable or large effusion, the apex-beat is lost, and the sounds of the heart are feeble and distant. The sound of impulsion is lost, leaving the mitral and tricuspid sounds, which are short and valvular like the diastolic sounds.

Increase or diminution of liquid in the second stage of pericarditis is readily determined by signs obtained by percussion and auscultation. When the quantity is much diminished, the friction murmur, if it have

been suppressed, returns, and persists until the pericardial surfaces become agglutinated. Not infrequently, by auscultating when the body of the patient is inclined forward, a friction murmur may be heard, notwithstanding the pericardial sac contains a large quantity of liquid.

In cases of chronic pericarditis with very large effusion, dilatation of the pericardial sac is shown by signs obtained by percussion and auscultation. There is no apex impulse, the heart-sounds are feeble and distant, the systolic sounds being short and valvular, and the precordia may be notably projecting. There may be systolic retraction at or near the apex-beat.

A malignant morbid growth filling the pericardial sac and inclosing within it the heart, may give rise to all the signs of pericardial effusion. A case of this kind, in a young subject, has fallen under my observation.

With reference to diagnosis, the etiological relations of pericarditis should be kept in mind. These are acute articular rheumatism, Bright's disease, tuberculosis, and either pleurisy or pneumonia. It rarely occurs in other connections, and, as an idiopathic affection, it is extremely rare.

The presence of air and liquid within the pericardial sac gives rise to loud splashing sounds which, occurring when respiration is suspended, and when pneumo-hydrothorax is excluded, are at once diagnostic of pneumo-hydropericardium.

FUNCTIONAL DISORDERS

Many of the so-called functional disorders of the heart are now recognized as due to distinct localized lesions of such parts of the heart and great vessels as have to do with the origination and conduction of cardiac contractions. For a summary of these the reader is referred to the description of irregularities of the pulse on page 252.

There are other groups of symptoms, in which disorder of heart action plays an important role, which have no constant or at present recognized structural cause, and some are evidently temporary disturbances of reflex cardiac nervous mechanism.

We may consider here angina pectoris, exophthalmic goitre, and palpitation.

By angina pectoris we mean an attack, or recurring attacks, of severe substernal pain, which is apt to radiate into the arms, and especially to the left arm, and is accompanied by a sense of impending death. In the majority of cases this is found to be due to obliterative diseases of the coronary arteries, and more particularly the orifices of these arteries at their origins in the aorta, this being often merely a part of a general, or extensive aortitis.

Examination of the heart during or between attacks may reveal nothing abnormal. It is upon the history and symptoms of the case, and not upon the physical findings, that the diagnosis is based.

Among the causes of rapid heart action is exoph-

thalmic goitre, in which the most constant of the three cardinal symptoms: enlarged thyroid, exophthalmos, and tachycardia is the persistently rapid heart action, which slows with improvement and increases in rate as the patient's condition grows worse. Here, again, there is no constant physical finding to account for the tachycardia, and at present we must class this among the symptoms due to a disorder of nutrition, of which the nervous unstability and loss of weight are other evidences.

By palpitation we mean a conscious distress in the region of the heart or epigastrium, accompanied by tumultuous, excessive, rapid, and often vigorous heart action. In some people this can be brought about by relatively slight reflex irritation, a sudden emotion of fear or joy, or indigestion, or it may develop during sleep, and without apparent antecedent irritation of any kind. The subjective symptoms, the manner of development, and the discovery of wholly normal conditions on physical examination, serve to make the diagnosis.

Palpitation as a subjective symptom may occur in failure of, or failing, compensation, in cases of high arterial pressure, and in cases of mitral stenosis particularly, among cardiac valvular disorders. It may accompany attacks of paroxysmal tachycardia, but its association with this condition is not constant, nor is subjective cardiac distress at all a constant accompaniment of even severe grades of advanced valvular disease with failing compensation.

In one point of view, the physical diagnosis in

functional disorders may be said to rest, not on negative, but on positive evidence. Percussion and auscultation afford the means, not only of excluding inflammatory affections and lesions, but of demonstrating the fact that the organ is sound at least as regards freedom from ordinary lesions. That its size is normal is shown by the normal situation of the apex-beat, of the lateral boundaries of the precordia, and of the area of the superficial cardiac space. That the valves are unaffected is shown by the normal characters of the heart-sounds. These positive facts, taken in connection with the absence of morbid signs, render the diagnosis certain. Positive assurance of the soundness of the organ should be withheld until painstaking examination of the heart, not only by auscultation and percussion, but by all the various accessory methods, such as the *x*-ray and electrocardiograph has been carried out. Thus will the opinion of the examiner carry the weight which is desirable, in order to secure for the patient relief from anxiety and apprehension.

Functional disorders are not infrequently associated with lesions with which they have no essential pathological connection. A patient with lesions which are either innocuous or attended with little, if any, inconvenience, may suffer from disturbance of the action of the heart produced by causes which are wholly independent of the lesions. There is a liability, in these cases, to the error of attributing the disorders to the lesions, and thus forming an exaggerated estimate of the importance of the latter.

To decide how much of the disturbed action of the heart is due to a superadded functional affection, is not as easy as to determine that lesions do not exist. The decision must be based on the character, degree, or extent of the lesions, as evidenced by the physical signs. In this connection may be stated a practical maxim which it is well to bear in mind whether functional disorders exist or not—namely, valvular lesions rarely give rise to much inconvenience until they have led to enlargement of the heart; and enlargement, either with or without valvular lesions, as a rule, does not lead to the serious effects which are characteristic of cardiac disease, so long as the enlargement is due to predominant hypertrophy, and not to dilatation.

CONGENITAL CARDIAC DEFECTS

There are three kinds of cardiac defects which give signs of enough constancy to be susceptible of diagnosis during life. They are transposed viscera, *i. e.*, a right-sided position of the heart, spleen, and stomach with a left position of the liver; defects of closure between the systemic and pulmonary circuits, *i. e.*, patent interauricular septum (patent foramen ovale); patent interventricular septum; patent ductus arteriosus, or ductus Botalli; defects in the formation of the tricuspid or pulmonary valves resulting in stenosis.

The signs of a right-sided position of the heart on inspection, palpation, percussion, and auscultation

differ from the signs obtained in normal individuals simply in the change from the left to the right of the mid-line. This condition must be sharply distinguished from a misplaced position of heart alone, a pathological state resulting from acquired inflammatory processes within the chest, and, of course, unaccompanied by the transposition of the abdominal viscera.

Patent foramen ovale may give no signs and interfere in no way with the life of the individual. It may cause death. There may be cyanosis and clubbing of the fingers. There may be a harsh systolic murmur, heard best over the second, third or fourth left interspaces, and not transmitted along the pulmonary artery. The murmur may be diffuse. It may be presystolic in time and it may be both diastolic and systolic.

Perforate interventricular septum may be congenital or acquired. The two causes of origin are to be distinguished by the history and records of examinations of the heart at different times. The usual signs are: a thrill over the precordium, extending throughout systole, and a loud rough systolic murmur heard best at the third to fourth left interspaces, near the sternum, and widely diffused downward to the left, and usually audible in the back.

Patent ductus arteriosus (ductus Botalli) presents fairly constant signs. There is usually a visible systolic pulsation in the second left interspace. There is a systolic thrill which may even continue through diastole. There are the signs of dilatation and hypertrophy of the right ventricle. There is an increase of

dulness to the left of the sternum, running from third to first rib, and across the manubrium of the sternum about one and one-eighth to one and one-half inches wide, indicating the dilated pulmonary artery. There is usually a loud systolic murmur of maximum intensity at the second or third left interspace, transmitted up to the top of the sternum and left clavicle. There may be an increased pulmonary second sound.

For diagnosis of tricuspid and pulmonary stenosis the reader is referred to descriptions of these lesions on pp. 293 and 294.

THORACIC ANEURISM

The physical conditions incident to thoracic aneurism which are concerned in the production of signs, are: the presence of a tumor within the chest, of variable size, formed by the aneurismal sac; the passage of blood into the sac with each ventricular systole, and the expulsion of blood in the diastole by the recoil of the coats of the aneurism; the size of the opening into the sac as affecting the quantity of blood which it receives with each systole; the quantity of stratified fibrin which the sac contains; the point of connection with the aorta of the aneurismal tumor, and the direction from this point in which the tumor extends, together with its relations to the lungs, the trachea, the primary bronchi, the intrathoracic veins, the esophagus, the recurrent laryngeal nerve, the sympathetic nerve, either the innominate

or subclavian artery, the ribs, sternum, and vertebral column.

With reference to diagnosis, it is well to bear in mind that, in the great majority of cases, an aortic aneurism is connected with either the ascending portion, or the junction of the ascending and the transverse portion of the arch, and that the tumor generally extends to the right in a lateral or antero-lateral direction. The physical diagnosis is more easily made when the aneurismal tumor is thus connected. The signs are less available if the aneurism arise from the transverse or descending aorta, and especially if the tumor extends in a direction downward or backward.

An aneurismal tumor which has made its way through the walls of the chest, or which, without perforation, causes a circumscribed bulging obvious to the eye and touch, presents the following diagnostic signs: An impulse is seen and felt which is synchronous with the ventricular systole. The force of the impulse is variable, depending, aside from the force with which the left ventricle contracts, upon the size of the orifice between the sac and the artery, and the quantity of fibrin which the sac contains. Following the impulse and coincident with the closure of the aortic valves, a shock (the diastolic shock) may often be perceived if firm pressure be made with the hand. A vibration or thrill with each impulse is sometimes a marked sign, but is often wanting. Frequently, but by no means constantly, a systolic murmur is heard over the tumor, and there may be also a diastolic mur-

mur produced by the passage of blood from the sac. Dilatation of the first portion of the arch of the aorta usually occurs, of a sufficient degree to establish an aortic regurgitation with its characteristic murmur. The heart-sounds are transmitted to the tumor with more or less increased intensity. There is notable dulness on percussion over an area corresponding to the space within the chest which the tumor occupies. If the tumor be of considerable size, it may produce condensation of lung around it; the area of dulness on percussion will be in this way extended beyond the limits of the tumor. Under these circumstances, bronchial respiration and bronchophony may be produced. If the aneurismal sac be beneath the integument, there may be to the touch a sense of fluctuation.

With the foregoing signs, the physical diagnosis scarcely admits of doubt. Some of the signs may be produced by a tumor, not aneurismal, so situated as to receive and conduct the aortic impulse. The chances of a tumor being so situated as to simulate the signs of an aneurism are few. I have met with a case of empyema in which perforation of the chest took place in the second intercostal space on the right side of the sternum, giving rise in this situation to a fluctuating tumor which had a strong pulsation. On a superficial examination the case seemed clearly one of aneurism; but an examination of the chest showed the right pleural cavity to be filled with liquid, and a puncture in the axillary region gave exit to a large quantity of pus, the pulsating tumor disappearing after a certain quantity of the purulent liquid had

escaped. I have met with a similar pulsating tumor, incident to empyema, on the posterior aspect of the chest.

When, from its small size or its situation, an aneurismal tumor does not come into contact with the thoracic wall, and when it is situated beneath the sternum, signs obtained by palpation and inspection being absent, the physical diagnosis is less easy. Important signs are: dulness within a circumscribed space situated in the course of the aorta; an abnormal transmission of the heart-sounds within this space, and the presence of murmurs. These signs are not always available, and when present they are not sufficient for a positive diagnosis. Other physical evidence, and the presence of certain symptoms, render the existence of aneurism highly probable, either with or without the foregoing signs. If an aneurismal tumor press upon the trachea, it occasions a tracheal rale, or stridor, together with weakness of the respiratory murmur on both sides of the chest. If the tumor press upon a primary bronchus, it occasions diminished or suppressed respiratory murmur on one side, and increased respiratory murmur on the other side of the chest. These physical signs should always lead to a suspicion of aneurism in a person over forty years of age. Symptoms which should excite this suspicion and lead to careful physical exploration for the physical signs of aneurism, are: dyspnea from spasm or paralysis of the muscles of the glottis, and aphonia or impairment of the voice without evidence of laryngitis, these symptoms

denoting either excitation or pressure of the recurrent laryngeal nerve; dysphagia from pressure upon the esophagus; congestion of the face, neck, and upper extremities from obstruction of the vena cava or the vena innominata; inequality of the radial, carotid, and subclavian pulsation on the two sides, or the absence of pulsation on one side, and contraction of one of the pupils. These symptoms not only render probable the existence of aneurism, but indicate its situation as regards the aorta and the direction in which the aneurismal tumor extends.

An aneurism may be suspected, wrongly, when, owing to shrinkage of the lung, or deformity of the chest, either the aorta or the pulmonary artery just above the heart is removed laterally from its normal situation, or brought into contact with the walls of the chest in the second intercostal space, so as to give rise to an appreciable impulse. A murmur may also be present at the point of impulse. An error of diagnosis under these circumstances is avoided by finding an adequate explanation of the signs just noted, and by the absence of other signs and of symptoms which are diagnostic of aneurism.

In conclusion, an aortic murmur, however intense or rough, is never evidence of aortic aneurism, and, on the other hand, the absence of murmur is by no means sufficient for the exclusion of aneurism.

CHAPTER IX

EXAMINATION OF THE ABDOMEN

Inspection—Palpation — Percussion—Auscultation—Stomach —Liver—Spleen—Kidneys—Abdominal wall—Other organs.

In making an examination of the abdomen it is presupposed that the anatomy and physiology of the walls and viscera have been already thoroughly mastered. The important points of the change of position of the abdominal contents during respiration; the change in size and position of the parts of the gastro-intestinal tract according to the amount and character of their contents; the changes incident to filling and emptying of the bladder; the alterations in the size and position of the uterus must all be kept in mind while examining the abdomen.

Inspection.—On inspection, we note the occurrence of normal or abnormal shadows, betraying the movements of viscera from the descent of the diaphragm, or in the course of peristalsis of their muscular walls. Prominences can be detected, especially with the eyes on the level of the abdomen, and the patient's feet toward the source of light, in the recumbent position. Pulsations are noticed. It is normal to see a slight epigastric systolic impulse. Peristalsis is not visible under normal conditions of the gastro-intestinal tract

except in extreme emaciation. Visible peristalsis almost invariably indicates obstruction, and the site of the obstruction may often be located by close attention to the direction, and point of cessation of the peristaltic waves. Peristaltic waves may be seen in the colon, when there is extreme or acute obstruction, which go in the normal and in the reverse direction. The lower and upper limits of the stomach, the lower border of the spleen and liver, the level of the uterus or a distended bladder may be observed on inspection. Tumor masses may be noticed as abnormal, fixed or movable prominences as shown by shadows. We observe the presence of obesity, the relaxed, pendulous, or contracted and sunken parietes. We look for edema, meteorism, dilated veins, paying particular attention to the system which is enlarged and the direction of flow. We notice whether there is support by the abdominal walls of their contents, or whether there is a general splanchnoptosis or prolapse of the viscera with downward and forward displacement. Inspection should be made in the dorsal, lateral, and erect positions.

Palpation.—Palpation of the abdomen is to be done with the patient in the lateral or dorsal positions, the abdominal walls being relaxed by posture and comfort of the patient. The examining hands should be warm and dry. To effect perfect relaxation examination may be made in a warm bath, or in extreme need under anesthesia. It may be necessary to empty the stomach, rectum, and bladder. We note resistance, fluctuation, the presence of a fluid wave, tumor

masses, sensitiveness to pressure, the movable borders of viscera, or the outlines of deeply seated and fixed organs. We may note aortic pulsation, the presence of mesenteric and retroperitoneal glands, and the anterior surface of the vertebræ in thin subjects. Errors may arise from reflex muscular tension, fat masses in the omentum, or mesentery, or attached to the gut, and from fecal masses.

Percussion.—Percussion of the abdomen is a less reliable guide than palpation. The note becomes more resonant with increase of gas in the intestine or in the free peritoneal cavity, but, with extreme distention of the intestine, the note loses its tympanitic quality; if there is gas in the free cavity there may be shifting dulness from coincident fluid exudate. There may be obliterated liver dulness whether the gas be free or in the intestine. The note is dulled by a diminution of gas in the intestines; presence of localized solid or fluid contents in the intestines; presence of localized inflammatory or neoplastic tissue superficially situated; by fluid accumulation in the free cavity, in which case the line of dulness or flatness should shift with the patient's change of position; and by thick abdominal walls.

Percussion of the stomach, colon, and small intestines is unreliable as compared with inspection and palpation; although very light percussion, or auscultatory percussion will give fairly accurately the limits of stomach and colon if distention with gas or fluid is used to exaggerate the notes.

Percussion of the borders of liver and spleen is merely confirmatory of facts better observed on palpation.

Percussion of the distended bladder gives marked dulness if a light stroke is used.

Percussion over the enlarged uterus gives a similar change of note, but palpation, catheterization, and vaginal examination serve to prevent confusion in this instance.

Percussion of the kidneys is unprofitable.

Auscultation.—Auscultation, except as combined with percussion, gives no positive results of value except in identifying the occurrence and location of the fetal heart-sounds, the uterine, placental, and cord murmurs in pregnancy, and murmurs due to the pressure of tumors on the abdominal aorta, or over abdominal aneurisms.

STOMACH

Examination of the stomach should include a determination by palpation and inspection of its size, location, character of its contractions, and its outlines when empty and when distended. Visible peristaltic waves seen passing from the left hypochondrium across the abdomen to end at the right of the umbilicus in a temporary prominence are diagnostic of pyloric stenosis. Points or areas of acute tenderness may be made out over its surface. Tumors of its walls or of the pylorus may be detected. By dipping, or quickly striking the wall, over the stomach we may elicit splashing when the stomach contains food, thus indicating its ability to empty itself, or its motility and the patency of the

pylorus. In spite of the apparent accuracy of some of these methods combined with the use of the stomach tube, there is no question that reliable x-ray examinations will give us more exact data as to size, location, and function than all the other methods combined, and this is equally true with regard to the other parts of the intestinal tract.

LIVER

The liver may be palpable in health owing to unusual shape of the costal margin or angle, or when displacement downward has resulted from faulty position or dress. The border may be palpable under these conditions even though its consistency is not unduly resistant. The liver may be displaced downward, or upward, according to the relation between the intrathoracic and intra-abdominal pressures, particularly in relation to the right side of the diaphragm in hydro- or pneumothorax, or in hydro-pericardium, and in meteorism, ascites, and pregnancy. The gall-bladder may be palpable and detected on percussion, to the right of midclavicular line at the costal margin, if it is distended by any of the obstructive affections which may interfere with the patency of the cystic duct. Detection of tenderness in the region of the gall-bladder, or just below it, may be an important point in distinguishing affections of the gall-bladder from more or less general abdominal pain, or appendical or gastric pains.

We find a slight enlargement of the liver in acute catarrhal jaundice.

In liver abscess the liver may be painful and irregularly increased in size.

In interstitial hepatitis (cirrhosis) there is usually uniform enlargement. The surface is firm and resistant, the edge hard, and unevenness may be detected. The spleen is usually enlarged as well. There is apt to be icterus and no ascites.

In carcinoma of the liver there is unequal enlargement, and a lumpy surface; there is usually icterus and ascites, but the spleen is not enlarged.

In echinococcus cyst of the liver there is usually a fluctuating tumor. Icterus is often present. The spleen is not enlarged, and ascites is not present.

In chronic passive congestion of the liver we find an enlarged, firm, sometimes tender liver. Icterus may occur but does not persist. The spleen is not enlarged, and ascites is not present, unless there is edema of dependent parts of the body or hydrothorax as well.

The liver may be enlarged in syphilis, when we find it hard and lumpy. The spleen large; ascites and icterus present or absent.

The amyloid liver is evenly enlarged, and smooth, and firm. The spleen is enlarged. No icterus or ascites.

In leukemia the liver is enlarged but to a less degree than the spleen. No icterus or ascites.

The liver is decreased in size in atrophic forms of chronic hepatitis, and in acute yellow atrophy of the liver. In the former we find an enlarged spleen, much ascites, slight icterus. In the latter we have extreme icterus, without enlargement of the spleen, or ascites.

SPLEEN

The outlines of the spleen can be determined by percussion, except for its posterior pole (*vide* p. 62).

By palpation, the lower pole of the spleen is to be felt if the spleen is enlarged. Palpation should always be carried out in two ways unless the spleen is easily felt. With the patient in the dorsal position, the examiner faces the patient, standing on his right side, and palpates gently in the left hypochondrium, the fingers of one hand pressing gently upon those of the other until the hand upon the abdominal wall is at or just beneath the costal margin at the anterior axillary line. The patient is directed to breathe in deeply, and as the diaphragm descends the soft tip of the spleen will be felt, with moderate enlargement. If this procedure fails, the examiner should stand at the patient's back while the patient lies upon his right side. The examiner, facing toward the patient's feet, hooks the fingers of his right hand over the costal margin, to feel the spleen as it is forced down in inspiration. When the spleen is markedly enlarged it may be missed if the examiner's hand is applied too near the ribs or too far posteriorly in the flank. Tenderness and unevenness of the margin may be observed.

If the splenic flexure of the colon is full of feces, the splenic dulness cannot be made out. If the stomach contains food, percussion over the spleen must be made with the patient on his right side.

Emphysema, meteorism, or ascites may cause a loss of splenic dulness. If the spleen is palpable, or the dulness reaches the anterior axillary line the spleen is enlarged. Enlargement occurs in many infectious diseases, especially in typhoid fever, and in malaria, typhus fever, and sepsis. The spleen is enlarged in cirrhosis of the liver, infarct of the spleen, amyloid disease, and the true and pseudo-leukemias. The spleen may be enormously enlarged without apparent cause, in tropical diseases splenic anemia, polycythemia, splenomegaly, and Banti's disease associated with types of grave anemia.

KIDNEYS

The kidneys cannot be percussed with profit. Changes of size and position can usually be determined by palpation. Palpation is used with the patient lying on his back, side, or abdomen, or in a semi-erect seated posture. An effective way of detecting a movable kidney is to grasp the abdominal wall gently with one hand, the palmar surface of the fingers against the lumbar muscles and the thumb pressing backward. The lower pole of the kidney if it descends on inspiration forces the thumb and fingers apart. By using bimanual palpation with one hand behind, just below the eleventh rib, and the other pressing back against the abdominal wall, the posterior hand appreciates increased resistance, as an enlarged kidney is forced down in inspiration. When freely dislocated even the upper pole may be palpated. Enlarged kidneys are not

so easily felt, nor do they so often move with the diaphragm, as do prolapsed kidneys. The colon is usually pressed forward by an enlarged kidney, the relative positions of colon and kidney being readily ascertained after artificial distention of the colon with gas.

ABDOMINAL WALL

Abdominal distention occurs in meteorism, which is a common incident in entero-colitis, typhoid fever, in peritonitis, and in obstruction of the gut. In peritonitis there is extreme tenderness either generalized, or, if the process is localized as an appendical abscess, inflamed gall-bladder or ruptured gastric or intestinal ulceration, the tenderness may be sharply circumscribed, with muscular spasm extending more or less widely. At a point half-way between the anterior superior spine of the ilium and the umbilicus, the tenderness of appendical inflammation is usually sharply localized (McBurney's point), and, if the colon is distended with air, this point may be the seat of acute pain in chronic inflammations of the same region.

In perforation of the wall of the stomach or intestine, there is apt to be a marked increase in the intensity of abdominal tympany, and liver and splenic dulness may disappear. With this, there is rapid weak pulse, and signs of a general peritonitis.

In obstruction of the gut, the signs may develop acutely or slowly according to the nature of the cause, whether kinking, intersusception or embolus on the

one hand, or progressive tumor growth, etc., on the other hand. The small, weak, rapid pulse, and absence of passage of flatus and feces, together with violent peristalsis, distention, and vomiting make the picture striking. The rectum and usual sites of herniæ should be examined.

The abdomen may be distended from ascites, in cardiac, renal, or hepatic disease, or in such peritoneal inflammations as occur in peritoneal carcinosis, and tuberculosis. In the latter two conditions there is often little or no tenderness of the abdomen, and in each condition the exudate may be localized, or capsulated, as it were, in some one portion of the peritoneal sac.

OTHER ORGANS

The rectum should always be examined digitally, and if necessary instrumentally. The bladder and vagina should be explored if there is any indication of interference with their function or structure, and often for the sake of determining the position of adjacent inflammatory or neoplastic processes. The stomach should usually be explored, information at the same time being obtained as to the patency and size of the esophagus.

CHAPTER X

EXAMINATION OF THE NERVOUS SYSTEM

General signs—Localizing signs— General examination of the nervous system—Motility—Sensibility—Reflexes—Trophic disturbances—Vasomotor disturbances—Electrical irritability—Special examination of nervous system—Examination of cranial nerves—Pathological gaits and postures.

GENERAL AND LOCAL MANIFESTATIONS OF BRAIN DISEASE

CERTAIN *general symptoms* may and usually do appear in the course of any cerebral affection, due to irritation, or cessation of its functions as a whole. A few phenomena occur which are of value, as convulsions, optic neuritis with characteristic ophthalmoscopic findings, variations from normal in pulse, and respiration rates, and in body temperature, disturbances in the secretion of sweat, vasomotor and nutritional disturbances.

Localizing symptoms occur also, and upon them we depend for determining what particular part of the brain is diseased, *e. g.*, spasm or paralysis of one or more extremities, or half the body, loss of sense of touch, pain, temperature or position of the extremities, or half the body, loss of sight, smell, taste or hearing, disturbances of speech. Unless the motor or

sensory areas of the brain are involved, all of these localizing signs may be lacking.

These general and localizing signs depend, not upon the character of the lesion, but upon its location and ability to produce destructive pressure.

General Signs.—*Convulsions* vary as to location, extent, duration, and sequence of the extension. They may be clonic or tonic, or combined. They may be preceded by a cry, the result of laryngeal or respiratory spasm, and there may be injury of the tongue, frothing at the mouth, and evacuation of the stomach, rectum, and bladder.

Optic neuritis is of slow development, not necessarily accompained by blindness, but there is a dimness of vision early, and loss of sight in advanced stages. By the ophthalmoscope, characteristic changes are seen in the optic disc, and retinal vessels.

Venous congestion, limited of degree or unilateral, with vascular relaxation, increased sweating and local edema, may be seen.

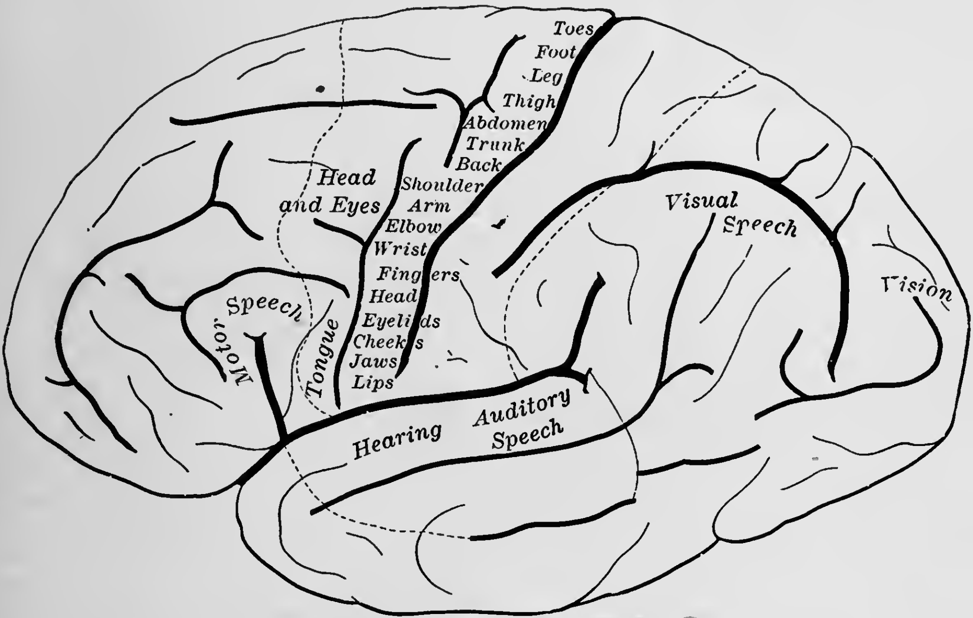
Emaciation may be severe, in spite of a sufficiency of food ingested, and ability to digest it.

Localizing Signs.—By noting the set of muscles first or chiefly involved in a spasm, the location of a cortical lesion may be determined with some accuracy.

Limited convulsive movements, or cortical spasms (Jacksonian epilepsy) may occur, followed by weakness or paralysis of the muscles involved in the attack, the subsidence of the paralysis occurring in an order, the reverse of the order of involvement at the time of the attack.

Paralysis of voluntary motion of one muscle, or many, may be present, while reflex acts involving the same muscles may occur, indicating a cortical as distinct from a subcortical or spinal paralysis.

FIG. 13



The functional areas of the cerebral cortex. Left hemisphere. (Starr.)

Aphasia of a motor or sensory type may exist, due to interference with complex cortical motor centres. *Dysarthria* or *anarthria* may occur from interference with the cortical centres for the facial muscles.

Monoplegia, hemiplegia, paraplegia, and *crossed* or *alternating paralyses* may occur, according as the lesion is small or large, or is at the cortex, or in the course of the motor tracts between the cortex, the base of the brain, the medulla and cord.

Disturbance of sensation may occur alone or with motor paralysis, the site of lesions to be determined by the same laws as are followed in analyzing motor paralysis.

Hemianesthesia, hemianalgesia, hemithermo-anesthesia, and hemiataxia may follow a cortical lesion of large extent or result from smaller lesions in the subcortical course of the sensory tracts in the internal capsule, crura, and medulla, the approximate location of the lesion to be determined by a knowledge of the anatomy of the ascending paths from cord, and medulla, to cortex.

Disturbance of Vision.—Since each optic nerve is supplied with fibres from each optic tract, any cerebral cause of blindness gives hemianopsia, as in occipital lobe lesions. The blindness may be for color vision, for one or two colors, or be total. Symmetrical blindness in both eyes is of cortical origin. Incomplete hemianopsia, with some blindness of the remaining fields, may occur in subcortical, or basal ganglia lesions in the vicinity of the terminations of the optic tracts.

Disturbance of hearing may prove to be a localizing sign, when the lesion is in both temporal lobes, or in the tracts leading from the ears to them.

Disturbance of the sense of smell is rare, and, if it occur, its significance is unknown.

Disturbance of sense of position giving a peculiar ataxic, staggering gait, but not in evidence unless standing or walking, may indicate a lesion in the vermes of the cerebellum.

Although no examination is complete without an estimate of the psychical condition of the patient, such tests form no proper part of the physical signs, present in diseases of the nervous system. There are, however, four distinct psychical states, occurring so frequently in general clinical experiènce as to be properly named here, viz., *depressed* and *irritative disturbances* of *consciousness; disturbances* of *intelligence,* and of *memory.*

The examination of the nervous system falls under the headings, general and special, as follows:

General: 1. Tests of motility.

2. Tests of sensibility.

3. Tests of reflexes.

4. Examination of trophic disturbances.

5. Examination of vaso-motor disturbances.

6. Tests of mechanical irritability of muscles and nerves.

7. Tests of electrical irritability of muscles and nerves.

Special: 1. Examination of the cranial nerves.

2. Pathologic gaits and postures.

GENERAL EXAMINATION OF NERVOUS SYSTEM

Motility.—Voluntary motions, with or without measured resistance, are undertaken by the patient at the examiner's order, giving evidence of more or less *paralysis, paresis,* or *motor weakness,* and confirming

evidence on inspection, of atrophy, or diminished size of the muscles tested. By testing symmetrical groups at the same time, even slight irregularities of power appear.

Motor irritation appears as involuntary muscular acts; *clonic spasms* repeated in series or shocks and chiefly incoördinated; *tonic* spasms, long continued rigid convulsions, as in tetany, tetanus, strychnine poisoning, meningitis; *contractures,* active or passive, the former a prolonged tonic spasm, disappearing under narcosis, the latter due to a shortening of the muscle; *fascicular* (or fibrillary) *twitching,* occurring in paretic, or paralyzed muscles, and similar to the action of healthy muscles exposed to cold; *tremor,* rapid, slight, rhythmic contractions, either occurring with increasing vigor with purposeful movements, the *intention tremor,* or occurring during inactivity. The intention tremor is peculiar to multiple sclerosis, and is essentially a clonic muscle reflex. The tremors of rest vary in their rate, location, and quality. Paralysis agitans tremor is slow (5 to 6 a second), first in the hands, coarse and largely inhibited by voluntary impulse. Senility gives a slow (4 to 6 a second) tremor first in the head, and intention may bring it out in mild cases, while in severe grades it persists during inactivity. In neuroses, and exophthalmic goitre we have a fine rapid (8 to 9 a second) tremor in the extended fingers. Toxic tremors are rapid, the type in alcoholism appearing first in the hands and lips. Vigorous muscular exertion, mental excitement and intense cold may give confusing tremors in health. *Choreic*

movements, aimless and involuntary, may involve the entire body, and prevent locomotion, and voluntary acts. Hemichoreic motions may occur in lesions of the posterior part of the internal capsule, or of the optic thalamus. If the movements are slow and regular, though aimless and involuntary, we call them *athetoid,* and these are seen in long-standing hemiplegias, and in Friedreich's ataxia.

Cataleptic rigidity, or a fixing of the limbs with a waxy, passive resistance, the position not being resumed when forcibly altered, occurs in hysteria, hypnosis, the psychosis katatonia, and rarely in the stupor accompanying brain tumor. *Myotonia* is an undue muscle tension occurring momentarily, and hindering the first of a series of voluntary motions, and is seen only in myotonia congenita or Thomsen's disease.

Ataxia or incoördination of muscular movements causes excessive or unexpected results of voluntary effort.

The patient is tested in the performance of coarse and then fine movements of the body and extremities, as standing, walking, touching nose with index finger, etc., the value of the tests being increased by shutting the eyes to cut off the aid of vision in directing the voluntary movements. Romberg's symptom consists in more or less noticeable swaying, in patients who stand with feet close together, and eyes closed, and in severe cases, even with the eyes open. It is evidence of disturbance of equilibrium, from anesthesia, or ataxia without anesthesia, in the lower extremities, and in affections of the cerebellum. Ataxia is a

typical finding in tabes dorsalis, and in Friedreich's ataxia, in motor cortical lesions, in polyneuritis (especially alcoholic) and occasionally in multiple sclerosis.

Interference with any member of the reflex or coördination arc may produce ataxia, whether the error be in the sensory limb, the psychomotor centre, the adjacent point of transfer to the centre from the centripetal limb, or in the motor limb.

Cerebellar ataxia, a result of cerebellar disease of the vermes alone, gives a peculiar reeling gait, while the arm and leg movements appear normal when the patient is in bed. A similar gait is seen where there is a loss of the usual stimulation of the cerebellum from the semicircular canals, or even from the auditory tract or from the eye muscles.

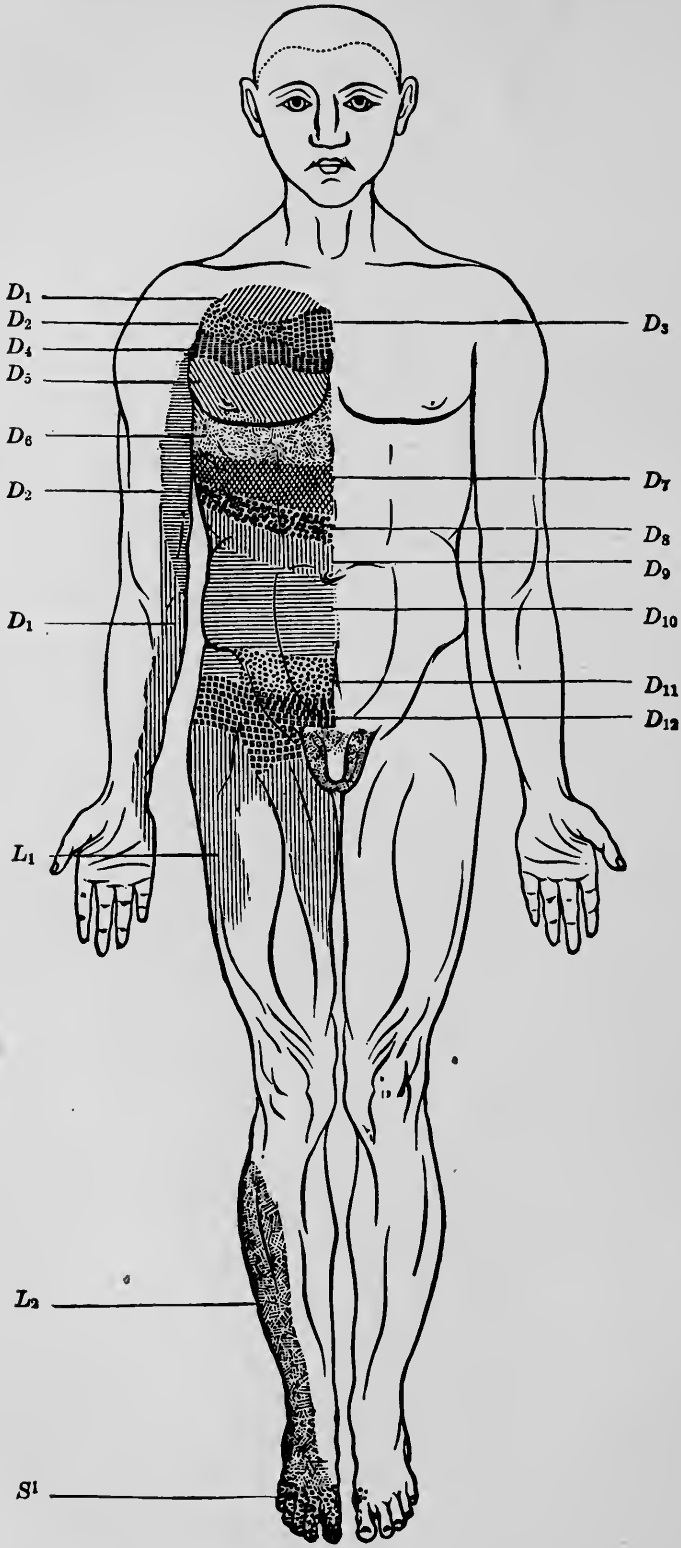
Sensibility.—Sensibility may be tested by delicate or firm pressure with cotton, hairs, the finger or metal weights or springs, and should be done with the patient's eyes shut. There may be increase, decrease, or absence of sensation of touch or pressure, *i. e.*, hyperesthesia, hypesthesia, or anesthesia. If a soft touch elicits pain or the stick of a pin fails to, we observe hyperalgesia or analgesia in particular areas. By using test-tubes with cold and warm water we can determine areas of altered or lost thermal sensibility. Particular areas of increased sensitiveness to pain, or so-called hyperalgesic zones, are recognized as constantly associated with diseases of deeper organs. The location of these various zones has been established by Head and Quincke (*vide* pp. 330 to 332).

Reflexes.—When testing reflexes it is necessary to avoid the inhibiting influence of the patient's attention to the particular act to be tested, and to be sure that the muscles involved in the act are fully relaxed before the reflex is elicited. The simplest device is to have the patient shut his eyes and pay attention to some question put to him by the examiner. Repetition may be necessary, but loss of reflex from fatigue may cause a faulty diagnosis of absence of reflex. The *cutaneous reflexes* to be tested are; *plantar:* plantar flexion of toes on tickling the sole of the foot; *cremasteric:* drawing up of the testicle when the skin on the inner surface of the thigh on the same side is lightly stroked; *inguinal:* contraction of the lower fibres of the internal oblique muscle on stroking the inner surface of the thigh; *abdominal:* contraction of transverse, oblique, and rectus muscles at the levels at which the of the abdomen is quickly stroked.

Tendon reflexes to be tested are the *knee-jerk,* or *patellar* reflex: contraction of the quadriceps extensor, when the patellar tendon is sharply struck as by the edge of the hand. *Ankle clonus* or Achilles-tendon reflex: single or persistently repeated plantar flexions of the foot, on making the Achilles tendon tense by passive dorsal flexion of the foot.

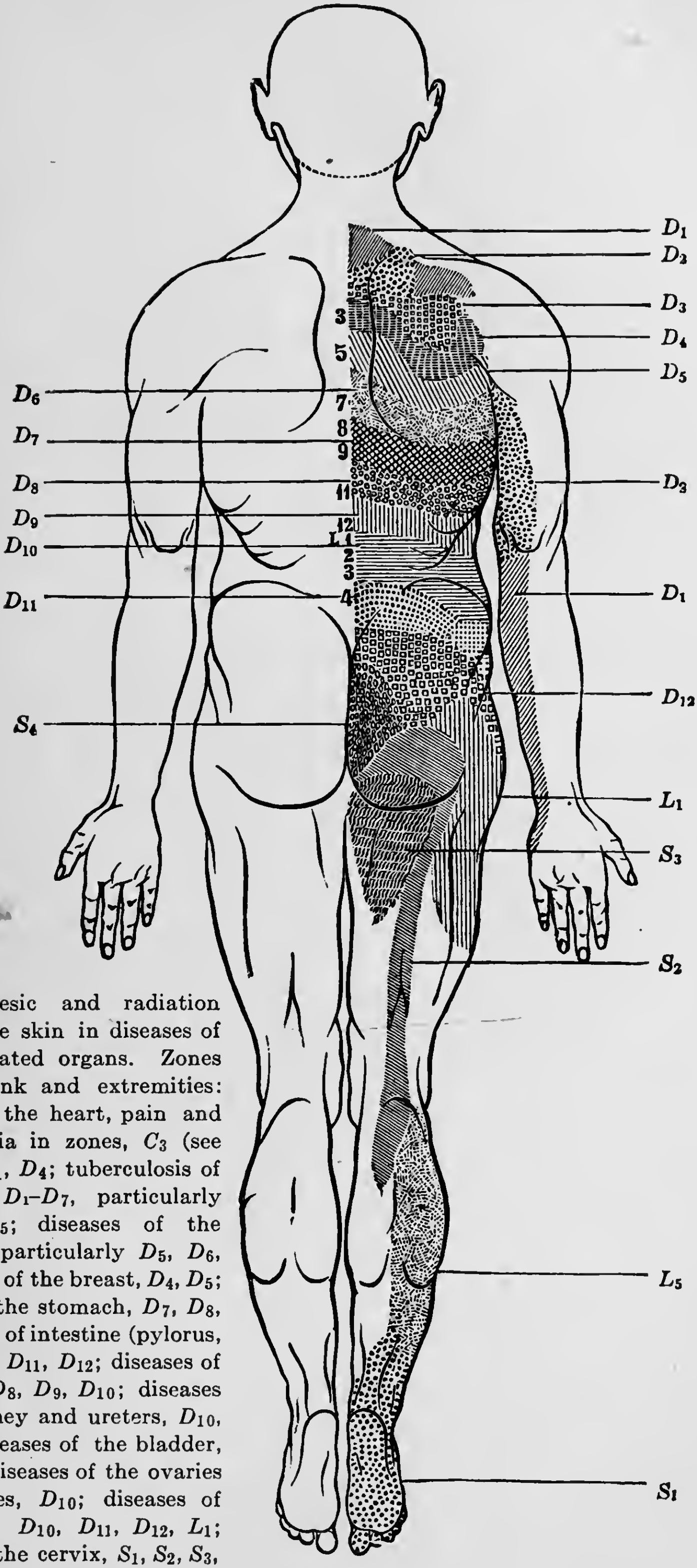
Other reflexes are frequent, on stretching individual muscle tendons or striking bony prominences or joints if there is a general increase in reflex irritability, but they are too inconstant in health to be important in disease.

Fig. 14



For description see Fig. 15.

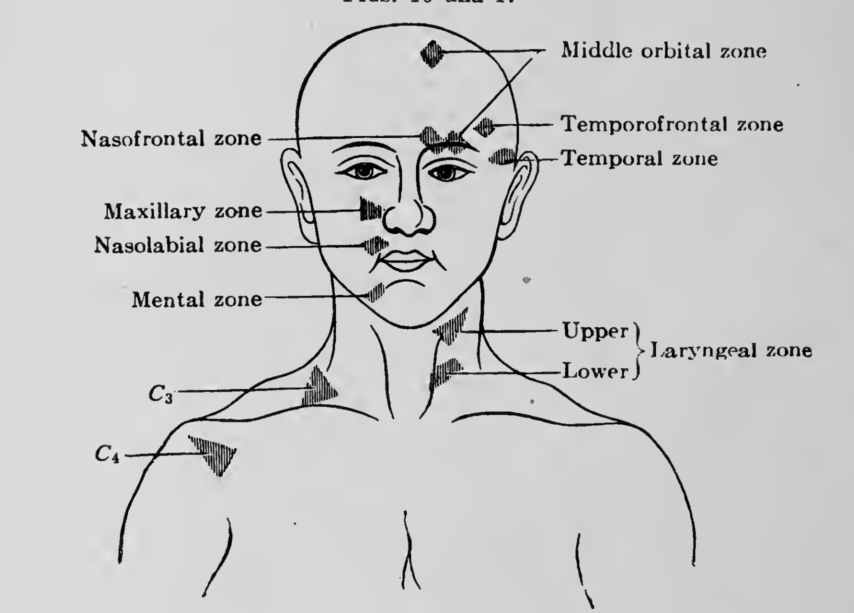
FIG. 15

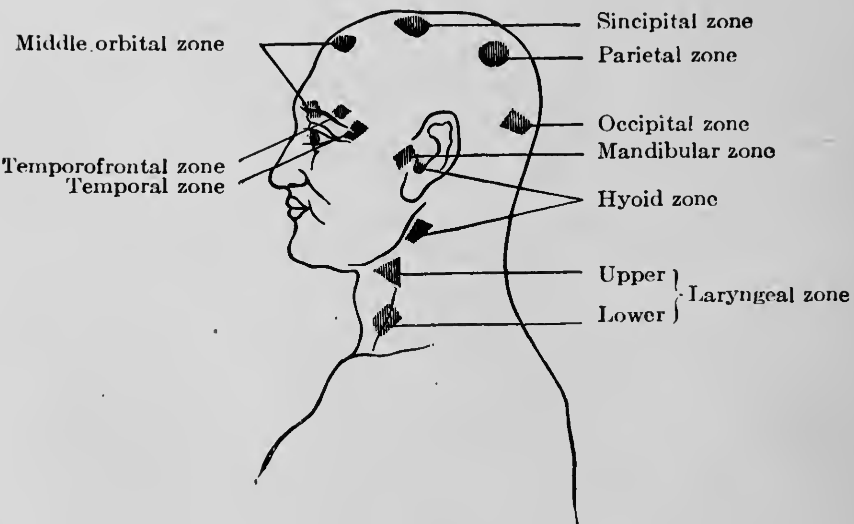


Hyperalgesic and radiation zones of the skin in diseases of deeply situated organs. Zones on the trunk and extremities: Diseases of the heart, pain and hyperesthesia in zones, C_3 (see Fig. 16), D_1, D_4; tuberculosis of the lungs, D_1–D_7, particularly D_2, D_4, D_5; diseases of the esophagus, particularly D_5, D_6, D_8; diseases of the breast, D_4, D_5; diseases of the stomach, D_7, D_8, D_9; diseases of intestine (pylorus, colon), D_{10}, D_{11}, D_{12}; diseases of liver, D_7, D_8, D_9, D_{10}; diseases of the kidney and ureters, D_{10}, D_{11}, L_1; diseases of the bladder, S_2, S_3, S_4; diseases of the ovaries and testicles, D_{10}; diseases of the uterus, D_{10}, D_{11}, D_{12}, L_1; diseases of the cervix, S_1, S_2, S_3, S_4. (After H. Head.)

The presence of normal reflexes is important, less reliable information being elicited when they are absent or increased.

Figs. 16 and 17





The Babinski phenomenon consists in a reversal of the normal plantar reflex, in that, when the sole of the foot is scratched, there is a dorsal flexion of the great toe, and usually a plantar flexion of the other toes. This is a pathological plantar reflex, and depends nearly always upon a lesion of the pyramidal tract.

Trophic Disturbances.—Trophic disturbances include affections of muscle, skin, bones, and joints. Muscles may be increased in bulk with increased strength physiologically, and pathologically in Thomsen's disease, and in congential hypertrophy. They may be increased in bulk, with decreased or stationary strength, where the increase is due to fat and connective tissue, *i. e.*, a pseudo-hypertrophy with a true progressive muscular dystrophy. Atrophy may result from disuse and be accompained by degeneration. If degeneration, *i. e.*, a pathologic proliferation of connective tissue occurs, we have a progressive muscular atrophy

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Description of Figs. 16 and 17.

Hyperalgesic and radiation zones of the skin in diseases of deeply situated organs. Zones on the head and neck: Nasofrontal zone, diseases of the eyes, nose, and upper incisors; middle orbital zone, in hypermetropia; temporofrontal zone, diseases of the ears and heart, temporal zone, in glaucoma. (After H. Head.)

Sincipital zone: Diseases of the middle ear.

Parietal zone: Diseases of the ear and stomach.

Occipital zone: Diseases of the posterior half of the larynx and certain abdominal viscera.

Maxillary zone: Diseases of the iris and vitreous body.

Mandibular zone: Diseases of the upper molars.

Nasolabial zone: Diseases of the nose and dental pulp.

Mental zone: Diseases of the incisor and canines.

Hyoid zone: Diseases of the tonsils, tongue, and lower molars.

Upper laryngeal zone: Diseases of the dorsal surface of the tongue and the wisdom teeth.

Lower laryngeal zone: Diseases of the larynx.

as a result of primary disease of the muscle, or secondary to interference in its nutritive control, by degeneration or inflammation of the nerve path, or of the ganglion cells in the spinal centres, and in the nuclei of the lower cranial nerves.

The muscular power may be diminished in proportion to the atrophy, or the power may be lost first, followed later by atrophy.

Trophic disturbances in the skin, occurring in a variety of severe diseases particularly in transverse lesions of the spinal cord, result in necrosis, as the bedsore or decubitus. Its distribution may be unilateral, as in severe cerebral hemiplegias. There may be areas of atrophy of the skin, causing a glazing, pigmentation, ulceration or gangrene.

Trophic disturbances of bones or joints may occur with interference of bone growth, or overgrowth of bone and cartilage at joints, as is seen in tabetic arthropathy, or Charcot joints. Hypertrophy of the bones of hands, feet, nose, and lower jaw sometimes associated with disturbed function of the hypophysis cerebri is known as acromegaly.

Vasomotor Disturbances.—Disturbances of sweat-secretion, increase or decrease, is of frequent occurrence, but of little diagnostic value. An exception is in the case of increased perspiration in acute polyneuritis, affecting the extremities, which occurs with enough constancy to be useful in diagnosis.

Electrical Irritability.—Electrical irritability of muscle and nerve is tested, by using unipolar stimulation of the muscle direct, or by application of the stimulating

electrode to certain accessible points over the nerve supplying a muscle. The strength of current, whether induced or direct, needed to elicit contraction, or the differences in the strength of contraction at symmetrical points on two sides of the body, with currents of equal strength, are used to determine variations in irritability of muscle and nerve.

Where there is a degeneration of muscle or nerve certain characteristic changes in electrical irritability are found, viz.: (1) Diminution or loss of Faradic irritability, or a decidedly weaker reaction than to galvanism; (2) a delayed and prolonged reaction instead of a sudden twitch; (3) a partial or complete reversal of the law of unipolar stimulation whereby the anodal closing contraction is greater than the cathodal closing contraction, instead of the reverse as is the case in health. Marked hyperirritability to galvanism is present before other signs develop in tetany.

SPECIAL EXAMINATION OF NERVOUS SYSTEM

Examination of the Cranial Nerves.—OLFACTORY NERVE.—Olfactory function is readily tested, but gives no reliable data, unless the condition of the mucous membrane of the nose is undoubtedly normal.

OPTIC NERVE.—The optic nerve function can be accurately tested by examining acuteness of vision after correction of errors of refraction, by plotting the field of vision with a perimeter for general and color fields.

In examining the function of the third, fourth, and sixth nerves it is well to bear in mind the muscles supplied by each, and then to consider the signs as observed upon the joint action of all three nerves rather than upon any one alone. The third cranial (oculomotor) nerve supplies the levator palpebræ superioris, rectus superior, rectus inferior, rectus internus, and obliquus inferior, the pupillary sphincter and the muscles of accommodation. The fourth cranial (trochlear) nerve supplies the superior oblique. The sixth cranial (abducens) nerve supplies the external rectus muscle.

1. We test the mobility of the eye in various directions, both with its mate and alone, while the head is kept fixed. Convergence upon a near point serves to test the internal recti. Rotation is tested by having the eyes follow the finger upward and outward, and then downward and outward. While looking upward and outward, rotation of the right eye in the direction of the hands of the clock, signifies paresis of the inferior oblique, and preservation of the superior rectus; while looking downward and outward, a similar rotation signifies paresis of the inferior rectus with intact superior oblique. Extreme paralysis of the eye muscles may result in strabismus.

Ocular muscle paralysis is due in almost every instance to lesions of the peripheral motor neurons; the nuclei of the ocular muscles being innervated by both hemispheres. A unilateral hemisphere lesion is ineffective, and bilateral ones extremely rare. When the lesion is purely peripheral the nerve is affected as

a whole, while if the lesion is nuclear, in the majority of cases the pupillary and accommodation fibres of the oculo-motor are not involved, since the oculomotor nucleus is distributed in different areas, the separate parts having, however, identical functions.

2. Ptosis, or a paralytic drooping of the upper eyelid, usually results from paralysis of the levator palpebræ superioris, supplied by a branch of the oculo-motor.

3. Conjugate paralysis, or deviation of the eyes, consists of weak or absent mobility of the two eyes to the same side, the patient looking toward his cerebral lesion, if the lesion is above the pons, and away from it, if the lesion is in the pons. It is a common symptom in such cerebral lesions as hemiplegia, resulting from hemorrhage or softening.

4. Nystagmus is a rhythmic oscillation of the eyeball, generally an intention tremor, but often occurring in extreme positions of the eye-ball, in many affections of the eye, of the brain, and of the labyrinth.

5. Gräfe's sign consists in a delay of the upper lid in following the eye-ball, as the eye is turned slowly downward, to follow the examiner's finger, thus showing a broad band of sclera above the cornea and giving a characteristic appearance to the patient in exophthalmic goitre.

6. Pupillary Phenomena.—A. A narrow pupil may result from exposure to bright light, during sleep, in old age, and during accommodation for near vision physiologically. A narrow pupil occurs pathologically, early in tabes dorsalis, and in progressive paralysis,

from the action of various drugs, eserine, pilocarpin, opium, advanced choloroform narcosis; from lesions of the pupillary dilating fibres of the cervical sympathetic, or lesions of the sympathetic itself, or of the oculo-pupillary fibres connecting the sympathetic nerve with the first dorsal segment of the spinal cord.

B. Dilated pupil occurs in loss of consciousness, in severe pain, in dyspnea, in peripheral blindness (optic atrophy and glaucoma), in general oculo-motor paralysis, rarely in tabes dorsalis, and progressive paralysis, and from atropin, duboisin, cocain, and early choloroform narcosis, and from the local application of epinephrin.

C. Inequality of the pupils may occur as result of unequal refraction of the two eyes in health. It is common in unilateral cerebral affections, tabes dorsalis, progressive paralysis, and in unilateral disease of sympathetic, oculo-motor, or optic nerves, and in migraine attacks.

D. Anomalies of pupillary contraction may occur, such as sluggishness or absence of the pupillary light reflex. The pupil may fail to contract to light, in bilateral cerebral pressure, in focal lesions which interrupt the reflex arc, in complete peripheral oculomotor paralysis, as a result of drugs mentioned as dilating the pupils, in affections of the retina, and in bilateral optic atrophy, or marked choked disk. The pupil may fail to react to light but retain its reaction to convergence and accommodation (the Argyll-Robertson phenomenon), a common early symptom of tabes dorsalis.

E. Accommodation varies with age, and with the refractive error of individual eyes. Making accepted allowances for the degree of presbyopia according to age, and correcting refractive errors, accommodation is tested with standard test type. Paralysis of accommodation is found in total oculo-motor paralysis, in lesions of the accommodation nucleus, and in diphtheritic paralysis.

Trigeminal Nerve.—Fifth cranial (trigeminus) nerve is to be tested for its motor part by observing the action of the chewing muscles. Their paralysis may occur as a result of cerebral lesions lying in the vicinity of the trigeminus nucleus, or affecting the efferent trigeminus fibres. The sensory distribution may be tested in the usual way, as far as the skin area is concerned. The sense of taste is to be tested with the tongue protruded, for if it were drawn in, to test the sensations produced by acid or salt, the glosso-pharyngeal nerve terminals at the base of the tongue would come into play and defeat the test. Corneal sensibility is tested, and the corneal reflex elicited, by touching the cornea with a small object, such as a pin head.

Seventh Cranial (Facial) Nerve.—Evidences of facial palsy are to be found in obliteration of wrinkles on the side affected, diminution or loss of voluntary movement, and of the reflexes. The cheek is relaxed, and flaps in breathing, the eye is open, the mouth drawn to the healthy side. The palate may hang lower on the affected side, the normal tear secretion may be affected, as the tear sac muscle is paralyzed, with resulting droop-

ing of the lower lid, and overflow of tears. The nasal opening on the affected side seems smaller, owing to paralysis of the levator alæ nasi. Saliva may escape on the paralyzed side owing to paralysis of lip muscles, and whistling becomes impossible. There may be a drooping of the ear on the affected side.

According to the position of the lesion, *i. e.*, supra- or infranuclear, the signs of paralysis are found to be different. A central paralysis (supra-nuclear) does not give paralysis of the upper facial muscles, nor interference with taste and secretory functions, although there is a less vigorous closure of the eye on the affected side. Neither atrophy of, nor electrical changes in, the facial muscles occurs in central facial paralysis.

In nuclear or infranuclear paralysis there is an increased acuteness of hearing especially for low notes on the affected side, owing to paralysis of the stapedius muscle. There is also some disturbance of taste, and diminished flow of saliva on the affected side, when the fibres of the chorda tympani nerve are injured.

Eighth Cranial (Auditory) Nerve.—The difficulty of eliminating disease of the ear itself, even by expert otoscopic examination, and the many doubtful conclusions as a result of even carefully made tests of air and bone conduction, make it apparent that diagnosis of auditory paralysis is an unreliable one. However, if the ear appears to be normal and both air and bone conduction of sounds, easily appreciated on one side, are not heard upon the other side, we may conclude that there is paralysis of the auditory nerve.

When simulation of deafness in one or both ears is suspected, various devices can be used to betray the patient into inconsistencies, and proove the simulation.

Ninth, Tenth, and Eleventh Cranial (Glosso-pharyngeal, Vagus, Spinal Accessory) Nerves.—Since these nerves receive fibres from both hemispheres as do the nerves supplying the eye muscles, unilateral hemispheric lesions cause little or no interference with their functions. The trapezius, except its clavicular portion, alone of all the muscles controlled by this group may show paralysis, because its fibres are for the most part entirely crossed and are thus often affected in a hemiplegia. Involvement of these three nerves in their course or in the medulla, *i. e.*, within the cranium, is evidenced by lack of palate control, interference with swallowing, imperfection in phonation, deficient closure of the glottis, choking, from inability to prevent access of foreign particles, swallowed or inhaled, to the larynx, imperfect cough, or entire inability to cough. Unilateral involvement of the recurrent laryngeal nerve causes narrowing of the glottis, and the affected cord remains in adduction. Obstruction, and effective stenosis, at the glottis may result from bilateral inferior laryngeal paralysis, and loss of sensitiveness of the larynx to foreign particles. Bilateral paralysis of the vagi may cause persistent tachycardia; unilateral vagus paralysis need not, and usually does not, affect the heart rate. Unilateral paralysis of the sterno-cleido-mastoid muscle causes a moderate twisting of the head to the paralyzed side with a slight elevation of the chin. Unilateral paralysis

of the trapezius gives various defects of position of the shoulder and arm according to the parts of the muscle that are affected, complete paralysis causing a falling of the shoulder, a prominence of the shoulder blade outward and upward and a slight impairment of power to lift the arm.

The Twelfth Cranial (Hypoglossus) Nerve.—The functions of chewing, swallowing, and speaking are noticeably interfered with in marked hypoglossal paralysis, although, in unilateral paralysis, it may be difficult to detect the errors, especially if a little time has elapsed and facility has been reacquired by practice.

Pathologic Gaits and Postures.—Characteristic gaits and postures are assumed in certain nervous diseases. We distinguish:

(*a*) The paraplegic gait: dragging of the legs slowly forward; (*b*) the hemiplegic gait: affected leg is dragged, twisted or swung forward by the pelvis; (*c*) the ataxic gait: random and incoördinate swing or stepping of the foot out of line, on the heels, or up in the air, coming to the ground hard; (*d*) the spastic gait: stiff or jumping movements of legs; feet hug the floor; knees tight together or stiff; (*e*) the gait in sciatica: the leg is fixed to the pelvis usually, the vertebral column is usually curved (convex to the affected side in the lower part and concave in the upper part); (*f*) the gait of propulsion and retropulsion: in paralysis agitans, inability to start or stop quickly; (*g*) the staggering gait: as seen in disturbances of equilibrium from the effects of alcohol, cerebellar tumor, diseases of the inner or middle ear, and lead encephalopathy.

CHAPTER XI

ACCESSORY METHODS AND ORDER OF PHYSICAL EXAMINATION

Accessory methods of physical examination—*X*-rays—Electro-cardiograph and electro-phonograph—Polygraph—Tonometer—Order of physical examination—Standard classifications of pulmonary tuberculosis.

ACCESSORY METHODS OF PHYSICAL EXAMINATION

WITH the value of early diagnosis appreciated, and with the benefit derived from the use of precise, rather than general estimates, and measurements of the physical acts resulting from bodily functions, in mind, certain instrumental procedures should be here mentioned, merely to call attention to the necessity of their employment in certain cases, and to insure the reader against considering that the unaided senses are always sufficient means for arriving at a diagnosis.

The *x*-ray, the electro-cardiograph, electro-phonograph, the polygraph, the tonometer, give us help, at times establishing a diagnosis, at others adding to its completeness.

X–Rays.—The differences between the various tissues of the body, in their capacity to obstruct or permit the passage of *Röntgen rays*, is made the basis of further

exact study of the position, and size of the viscera in health, and of alterations in size, position, structure, or presence of adventitious material in disease.

The *orthodiagraphic* method of using the rays obviates the error due to dispersion of the rays, and permits accurate outlining of organs, at rest or when altered in shape and position by movements of their own or the parietal musculature, as in outlining the heart and great vessels or dilatation of them.

By the *stereoscopic method* of studying the results of Röntgen ray exposures, an optical illusion is produced, which makes objects appear in their relations in three planes of space, instead of in only two dimensions.

In the lungs, assistance may be had in some cases where tuberculous processes seem to give no physical signs, or but doubtful ones on percussion or auscultation.

Inflammations of the pleura and lungs, when not positively identified or exactly localized by physical examination, are often clearly shown by the Röntgen rays. The position and size of the heart, and great vessels, may be determined with more accuracy than is possible by percussion and auscultation.

In the gastro-intestinal tract, invaluable, and otherwise unobtainable, information may often be had by the use of bismuth mixtures in stomach or colon, or both. The resistance of bismuth to Röntgen rays makes it possible to get much information as to the size, position, patency, location of obstruction if any, functional activity, duration of passage of food mass, and relations of the various parts of the gastro-

intestinal tract to each other, to other organs or to inflammatory and neoplastic structures within the abdomen. Examination is often profitably made before and after emptying the colon.

By study of the movements of the diaphragm with the *fluoroscopic screen,* and by exposures, with the breath held at different phases of respiration, positive conclusions can be had in otherwise obscure conditions above and below its surface.

Information as to the presence and location of suspected foreign bodies, of a resistance to Röntgen rays different from that of the normal tissues of the abdomen and thorax, is usually obtainable with precision.

Under certain conditions, intracranial tumors may occasionally be detected by their density, or their determination of distortion of the bony parts of the cranial bones, or their association with abnormal bony development. We may learn much as to the presence of any of the surgical conditions of the bones and joints of the body.

Wherever the condition of the patient allows of it, and the equipment, and an expert to use the instrument, and to interpret the results are available, the Röntgen ray should be employed in any but the most obvious disorders of inaccessible parts of the body.

Electrocardiograph and Electrophonograph.—While the diagnosis of valvular defects of the heart, or defects in its muscular action, is usually determinable by physical examination of the chest, there are many phases of the heart's functions, points in its rhythmicity, conductivity, contractility, and origination of its

impulses which can be suspected, but not proved, except with the aid of such instruments as the electrocardiograph, and the electrophonograph. By recording the incidence, and passage of the currents of action in the heart, and by making synchronous records of the sound vibrations produced by the heart, and of the peripheral physical sequelæ of the heart beat, much of value to the diagnostician as well as to the physiologist and pathologist has been made a matter of record and comparison.

Polygraph.—When the expensive and elaborate paraphernalia necessary for electrocardiographic records is not available, the simpler machinery for noting movements of the heart, and of the blood in the arteries, veins, or viscera at a distance from the heart, as by the polygraph, often adds to the accuracy of a physical diagnosis.

Tonometer.—In spite of training, and natural delicacy of touch, and minute attention on the part of the examiner, the physical factors of the blood flow are but imperfectly observed by a digital examination of the pulse. The simple procedure of measuring the systolic, and diastolic pressures in the arteries of the body, as in those of the arm or lower leg, if necessary in different positions of the body, is so important a maneuver that it should form a part of every physical examination. There are many methods and instruments available for this procedure.

ORDER OF PHYSICAL EXAMINATION

For the sake of having a reasonably complete record of a physical examination, it is imperative that the student should become so used to a logical and definite order that omissions are unlikely to occur. To this end the following scheme or order of physical examination is included:

General Appearance.—Height, weight, nutrition, type of physique, active and passive posture. Expression.

Constitutional Signs.—Body temperature. Pulse rate. Respiration rate.

Psychical Conditions.—Intelligence, consciousness, restlessness, convulsions, delirium, apathy, stupor, coma, speech, memory.

Skin.—Texture, color (cyanosis, icterus, pigment), moisture, temperature, edema, emphysema, hemorrhages, insect bites, eruptions, scars, collateral, venous, or capillary circulation, striæ, desquamation.

Head.—Shape and size, symmetry.

Eyes.—Position, motion, equality and size of pupils, reactions of pupils to light, and accommodation, acuteness of vision, conjunctivæ.

Ears.—Hearing, mastoid tenderness, tophi.

Nose.—Patency of nares, or obstructions, odor, secretions.

Lips.—Color, moisture, eruptions.

Teeth.—Gums swollen, puffy, pyorrhea, lead line, caries, absence, saliva.

Palate.—Broad, narrow, arched, perforated.

Neck.—Glands, lymph-nodes, thyroid, enlargement or pulsations of veins and arteries, thrills, murmurs, venous hum.

Larynx.—Tracheal tug, cough, voice.

Pharynx.—Color, exudates, tonsils.

Esophagus.—Swallowing.

Vertebræ.—Curvature, tenderness.

Chest.—Variations in breadth or depth, asymmetry of form or function. Abnormal impulses. Shape, funnel, rachitic, with rosary, and costal groove. Scapulæ position. Expansion, measurement. Unilateral or bilateral bulging or retraction of interspaces.

Respiration.—Rate, type, diaphragm phenomenon, retraction of interspaces, Biot's or remittent breathing. Cheyne-Stokes or periodic breathing, dyspnea, inspiratory or expiratory, cough, expectoration.

Palpation.—Fremitus, vocal, bronchial, pleuritic.

Percussion.—Systematic, of whole chest. Particular attention to comparison of apices and determination of lung borders in inspiration and expiration.

Auscultation.—Breath and voice sounds, adventitious sounds.

Heart.—Inspection, apex, location and character of beat; presence of abnormal pulsation.

Palpation.—Site and character of apex-beat; site and time of thrill or abnormal pulsation.

Percussion.—Borders of heart, change on altered position.

Auscultation.—Character of first and second sounds, or their component parts at the several valvular areas, murmurs, place, time, maximum intensity, direction of transmission, character, effect of change of position.

PULSE.—Size, force, frequency, rhythm, tension (instrumental determination), vessel wall, character, symmetry on two sides, delay.

ABDOMEN.—Form, circumference, umbilicus, resistance, percussion, palpation, visible movements, tumors, size, consistency, mobility, relation to respiration and to other organs, fluctuation, tenderness, auscultation of abnormal sounds.

LIVER.—Upper limit, lower border, character of surface and edge, smooth, nodular, tender, pulsating.

SPLEEN.—Area of dulness, edge, character of surface.

STOMACH.—Size, visible movements, splashing, tenderness, tumors, if necessary distention with gas or fluid and use of tube to empty.

KIDNEYS.—Palpation; bladder, retention, palpation, and percussion.

EXTREMITIES.—Joints, movements, size, tenderness, musculature, atrophy, hypertrophy, altered tonicity, trophic abnormalities. Lymph-nodes, inguinal, axillary, and epitrochlear.

Reflexes.—Tendon, joint, skin reflexes, also general sensibility, locomotion, and muscular efficiency.

Special examinations to be made whenever necessary to a complete diagnosis. Ophthalmoscopic, laryngoscopic, and rhinoscopic, otoscopic, rectal, vaginal, urethral, and cystoscopic, special neurological tests, sounding of esophagus and stomach.

STANDARD CLASSIFICATIONS OF PULMONARY TUBERCULOSIS.

For the sake of accuracy in using terms descriptive of the various stages or degrees of severity of pulmonary tuberculous lesions, the student is advised to avail himself of the definitions which follow.

A. Turban's Classification.

According to Turban we may define the lesion as of three grades:

By grade I, we mean a slight lesion extending at most to the volume of one lobe or two half lobes.

By grade II, slight lesion extending farther than I, but at most to the volume of two lobes; or a severe lesion extending at most to the volume of one lobe.

By grade III, all lesions which in extent of the parts affected exceed II.

By "slight lesion" we understand disseminated centres of disease which manifest themselves physically by slight dulness, by harsh, feeble, or broncho-vesicular breathing, and by rales.

By "severe lesion" we mean cases of consolidation and excavation such as betray themselves by marked dulness, by tympanitic resonance, by very feeble broncho-vesicular, bronchial or amphoric breathing, by rales of various kinds.

Purely pleuritic dulness, unless marked, is to be left out of account; if it is serious the pleurisy must be mentioned under the head of tuberculous complications.

B. The National Association Classification.

The National Association for the Study and Prevention of Tuberculosis has adopted the following classification:

Incipient (Favorable).—Slight initial lesion in the form of infiltration limited to the apex or a small part of one lobe. No tuberculous complications. Slight or no constitutional symptoms (particularly including gastric or intestinal disturbances or rapid loss of weight). Slight or no elevation of temperature, or acceleration of pulse at any time during the twenty-four hours, especially after rest. Expectoration usually small in amount or absent. Tubercle bacilli may be present or absent.

Moderately Advanced.—No marked impairment of function either local or constitutional. Localized consolidation, moderate in extent with little or no evidence of destruction of tissue; or disseminated fibroid deposits. No serious complications.

Far Advanced.—Marked impairment of function, local and constitutional. Localized consolidation intense; or disseminated areas of softening; or serious complications.

Miliary Tuberculosis (*vide* page 210).

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